

SCIENTIFIC REPORTS

OF THE

Indian Agricultural Research
Institute, New Delhi

For the year ended 30th June, 1947



PRINTED BY THE GOVERNMENT OF
INDIA PRESS, CALCUTTA, INDIA, 1947

Price Rs. 3 and annas 14 or 6 sh. 3d.

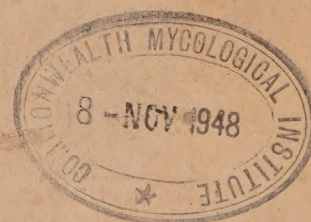


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REPORT OF THE DIRECTOR

I.—INTRODUCTORY

Reference was briefly made in the last report to plans for the expansion of the activities of the Institute and to necessary changes in the set-up which had been introduced to enable the Institute to fulfil its functions as a major centre of fundamental research and advanced training in the agricultural sciences. Of the three new Divisions sanctioned as part of the expansion scheme, the Divisions of Agricultural Economics and of Statistics have not yet been organized and the Agricultural Engineering Division is still in the initial stages of development. Because of this, the contemplated post-graduate courses in Agricultural Economics and Agricultural Engineering have not yet been started. In the case of the Division of Agricultural Engineering, the Head of which was appointed at the end of 1945, recruitment of other staff has just begun but no part of the projected workshop has yet been constructed. Some progress has, however, been made in equipping the existing workshop for repairs, enabling the farm machinery and implements to be maintained in working order.

Staff

The activities of the Institute were greatly handicapped through the depletion of the scientific staff. Five senior members left to take up other posts and eighteen including research assistants were either away on study leave or went abroad on government scholarships and two were to go abroad shortly. In addition to these, five senior men and thirty-four scientific assistants, field staff, etc., will be leaving for Pakistan shortly. The position has been still further aggravated by the difficulties encountered in making recruitments to new posts sanctioned under the expansion scheme, as a result of which many important posts are still unfilled. This is largely the result of the comparatively poor grades of pay prevailing at the Central Institute and it is hoped that this will be rectified by the decisions of government on the recommendations of the Pay Commission. The multiplicity of scales of pay of the non-gazetted scientific staff which created confusion and discontentment has been removed under a scheme which has been approved by government; the staff concerned is now grouped into Research Assistants, Senior Scientific Assistants and Junior Scientific Assistants, with appropriate scales of pay.

Equipment

Great difficulties have been met with also in purchasing scientific equipment and machinery. Practically no equipment has been purchased by the Institute during the war years and much of the moderate equipment which existed prior to this is in pressing need of replacements; new equipment is urgently required to introduce new techniques or undertake new lines of research. The purchasing power of money is now only about

30 per cent. of its pre-war value. Then there are difficulties associated with availability of apparatus, etc., for export in the manufacturing countries, import licenses and permits, and dollar control in the case of countries lying within the dollar currency area. There is also no proper glass blowing workshop and the existing workshop is ill-equipped. It has, however, been possible to make some headway. The requirements of the different Divisions have been formulated and orders placed both in India and abroad.

The Institute has been able to purchase from the Calcutta University at a cost of Rs. 16,086 certain instruments and apparatus which include a Spectrograph, Galvanometer, and accessories required for work on Colloid Soil Constituents and Trace Elements. These two schemes which were previously being carried out at the Calcutta University have been transferred to the Institute.

The full range of instruments required for recording the meteorological observations which are necessary for correlating studies on plant growth, and the incidence of pests and diseases, etc., with climatic factors are not available at present even at the main farm at Delhi. Arrangements are being made to provide for these, in consultation with the Meteorological Department of the Government of India, both for Delhi and the sub-stations at Pusa, Karnal, Simla and Coimbatore. The instruments ordered include a special Australian type of evaporimeter.

Buildings

Additional accommodation required for the Engineering workshop, laboratories and residential purposes has constituted a bottleneck. By far the major portion of what was required and provided for has not been constructed. The additional wings for the Entomology and Mycology Divisions have, however, been completed and also the first block of the new hostel accommodating 100 students minus the servants' quarters. The Auditorium, the building for the Divisions of Agricultural Economics and of Statistics, the Engineering workshop, additions to the Botanical Laboratory, and residences have not been built and the work on all these items has yet to be started. The slow progress in taking up works which have been sanctioned and for which funds have been provided, and which appears to be unavoidable under the present system, definitely hinders the fulfilment of the research and training programme laid down for the Institute.

Library

An urgent item is the air-conditioning of the valuable Linlithgow Library which is the best library of its kind in the country. A sample survey showed that owing to the climate prevailing in Delhi, 15 per cent. of the samples had perished while another 22 per cent. were developing symptoms of deterioration. Sanction has accordingly been obtained for the air-conditioning of the Library and steps are being taken to instal a suitable plant for the purpose.

The Library Building has been enriched by a collection of paintings by Nicholas Roerich, and some other artists of note, generously presented by Mr. M. S. Randhawa, Deputy Commissioner, Delhi.

Fire Protection

Another matter in relation to buildings, the library, equipment and valuable collection of plant and other materials, which received attention was that of fire protection. Steps have been taken to obtain a large number of soda-acid and foam-type fire extinguishers and distribute them throughout the Institute to deal with the risk of accidental outbreaks of fire in the laboratories and offices.

Activated Sludge Plant

The present activated sludge plant for the disposal of sewage at the Institute is designed for a population of 1,500 only. As the plant would not be able to cope with the needs of the residential population, it has been decided to instal a septic tank in stages, the effluent therefrom being mixed with that from the existing activated sludge plant. In due course, the sewage system of the Institute will be linked with the New Delhi Municipal Committee's system when that is extended on this side of the city. The present activated sludge plant will be maintained for demonstration and study.

Irrigation

Consideration was given to the problem of irrigation. The present unlined open channel system results in losses of considerable quantities of costly water by seepage (and evaporation), and a steady rise of the sub-soil water was noticed with the attendant risk of water-logging of the farm fields. The Institute has been paying about Rs. 65,000 a year for water for irrigation which has proved inadequate for the total cultivated area. A proposal for laying hume pipes for the distribution of the water has been approved by Government. Suitable meters will be installed so that payment in future will be on the basis of water actually consumed by the Institute for irrigation, and it will also be possible to determine the quantity of water actually applied to a particular field; the latter is obviously very important for experimental purposes.

At the Karnal Sub-station Farm, out of a total cultivable area of 1942 acres, only a small portion can be adequately irrigated at present, leaving by far the major portion dependent on the rainfall. To expand the irrigation facilities, a proposal for sinking two tube-wells was approved in 1942 and sanction was received for a third in 1945; but for some reason or the other, the work has not yet been taken up.

Functions of the Institute

It will not be inappropriate to turn aside here and briefly refer to the functions of the Central Agricultural Research Institute. Obviously, its main functions must be (a) to advance the knowledge of the agricultural sciences with the objective of improving the theory and practice of agriculture, and (b) to impart training of the highest standards in the different agricultural sciences including training in research methods. In order that the results of the work done at the Institute may have sufficiently wide application, it is necessary to undertake and repeat experiments and trials in different regions having marked variations in soil and climatic conditions so as to arrive at accurate conclusions. To ensure this, this Institute should have sub-stations in different parts of this Sub-continent and also arrangements should be made for close liaison with Provincial and State Departments of Agriculture and with Commodity Research Stations. A body of men conversant with the principles and practices of husbandry as prevalent throughout the country is necessary for various purposes and the persons trained in the Central Institute with the abovementioned facilities will have such grounding for which Provincial Institutions cannot cater.

During the year, the Tobacco Research Sub-station which was founded and developed by the Institute with funds provided by the Indian Council of Agricultural Research, was transferred to the Indian Central Tobacco Committee. It is likely that the sub-stations at Simla and Bhowali will be taken over by the Central Potato Research Institute which is expected to be established in the immediate future. Unless the facilities which these sub-stations provided for experiment and trial are replaced in some way, even the current work of the Institute will suffer a set-back. This applies particularly to the Simla Sub-station, where our potato and wheat collections are being

maintained and where experiments under the scheme for breeding 'rust' resistant wheat for the hills are located.

The permanent manurial plots and the lysimeters at Pusa which are of great scientific and practical interest have not been receiving the attention they deserve. Steps have been taken to revive interest in these.

The research and investigations conducted during the year are described in the reports of the Divisions, and attention is drawn to their salient features in the next section of this report. It will be apparent from a perusal of these that some progress has been made in spite of the various difficulties that have been alluded to. Besides research, a good deal of attention was paid to advisory work and students' training.

Advisory and Survey Work

A large number of important enquiries from Government, the Indian Council of Agricultural Research and other bodies, both official and non-official, was dealt with and several comprehensive notes were furnished. Rapid soil surveys more or less of a reconnaissance type were carried out at Ajmer, where it is proposed to provide irrigation by constructing a reservoir in the Gauri Kund Hills; at Jubbulpore to ascertain the suitability of the area selected for establishing a Central Cattle Breeding Farm, and at Bhadrak Military Farm, Lucknow, where it is proposed to locate an Agricultural Research *cum* Sugar Technological Institute of the Indian Central Sugar-cane Committee. A reconnaissance survey of soils in the Great Rann and Little Rann areas of Cutch was also made, at the request of the North Western Railway authorities.

Advice and assistance was given to Jaipur State. The Head of the Division of Botany paid visits to the State in March-April and September, 1946 and again in April, 1947. Earlier in 1945, he had visited the State and made recommendations regarding the improvement of wheat, barley and other crops, and also on some other projects such as the proposed Botanic Gardens and the development of the existing Nullah Gardens. The visit in March-April, 1946, was intended to follow up mainly the breeding work on wheat and barley, especially the former, as a large number of new strains evolved at the Institute had been supplied to the Director of Agriculture, Jaipur, for preliminary trials. The visit paid in September, 1946, was undertaken principally with the object of advising the State Department of Agriculture on the breeding of *bajra* which is the most important *kharif* crop grown in the State. The tour made in April, 1947, showed that a few of the new strains supplied by the Institute had yielded well in spite of the severe rust epidemic and were distinctly superior to the local variety used as control. On an invitation to advise the State regarding (a) the suitability of water of the Jal Mahal Lake and the wells in the neighbourhood for irrigation purposes, and of the soil in the site selected for the proposed Botanic Gardens at Jaipur, and (b) the soil work in general being carried out in Jaipur, the Director paid a visit to the State in December, 1946, and submitted a comprehensive report.

Advice and help were also given to Bhopal State and the centrally-administered areas of Ajmer-Merwara and Baluchistan. In Bhopal, a scheme for eradication of *kans* is being worked out with the advice of the Heads of the Divisions of the Agronomy and Engineering under the administrative control of the Director.

In March, 1947, the Director in company with the Heads of the Divisions of Agronomy and Agricultural Engineering paid a visit to Bhopal to inspect the work in progress in connection with the *Kans* Control Scheme and discussed with the Director of Agriculture, Bhopal, the lines of further work.

In October, 1946, Head of the Division of Mycology paid a visit to the N.-W. F. Province and inspected the Farms and Fruit Gardens at Parachinar, Kohat, Tarnab, and the Alizai Citrus Garden (Kurram Valley). In the last-named garden an infectious citrus disease was causing havoc by killing outright most of the citrus plants there. The Head of the Division after close inspection tendered valuable suggestions for remedial measures to control and combat the diseases observed by him.

The Mycologist in Baluchistan, Quetta, wanted to import the fungus *Urocystis orobanchas* for tests to ascertain its utility as a means of control and at his instance the Development Officer in Baluchistan asked for a permit from the Head of the Division of Mycology to import live culture of the fungus. It was contended that this fungus would not attack any host except orobanche. The Head of the Division of Mycology after consulting Dr. Wiltshire of the Imperial Mycological Institute, England, felt unable to support this proposal in view of a distinct danger in introducing a parasitic fungus which does not occur in India. Copies of the correspondence on the subject were forwarded to the Government of India in the Ministry of Agriculture, who in their turn have forwarded copies of the same to the Government of Pakistan, as Baluchistan has since come under the administrative control of the latter Government.

Among the notes which were prepared by the Institute in the course of the year mention may be made of one on "wheat rusts and their control" which was prepared in connection with a conference convened by the Hon'ble Minister in charge of Food and Agriculture to discuss the situation created by the wheat rust epidemic in Central and Peninsular India and the steps to be taken to avoid losses from this source in future. The note which has been circulated to Provincial and State Mycologists and Wheat Breeders aroused considerable interest and has also been sent for publication.

A consolidated note was sent to the Indian Council of Agricultural Research on the experiments done in several stations on the comparative value as nitrogenous fertilizers of salvaged ammonium nitrate and ammonium sulphate. The conclusion is justified that ammonium nitrate is as good a source of nitrogen for plants as ammonium sulphate. The nitrate has some advantage in that it is half as acidic in its effect on soil as the sulphate and contains nitrogen in a more concentrated form, thus lessening transport cost. The cost of production per unit of nitrogen should not be a difficulty. It has also the advantage that it does not require gypsum or sulphur for its preparation. It has also in it both the ammonium and the nitrate groups. It is, however, more liable to be lost by leaching. Its explosive properties do not stand in the way of its use in large quantities. Storage under humid conditions, however, presents difficulties. Tests with imported ammonium nitrate in bulk have shown that in suitable granular form and conditions of packing it can be satisfactorily stored in places like Calcutta and Madras. A note was sent to Government on the desirability of manufacture and procurement of nitrogenous fertilizers of types other than ammonium sulphate which have their applicability under varying conditions of soil and cropping.

A questionnaire from the Indian Tariff Board regarding the protection or assistance for the super-phosphate industry was referred by the Indian Council of Agricultural Research to the Director. It has been pointed out that if crop production in India has to be stepped up, as it must be, our demands for super-phosphate, rock phosphate, bone-meal and other forms of phosphatic fertilizers may ultimately go up to the order of million tons.

In response to a request from the Secretary, Economic Research Department of the All-India Congress Committee, Swaraj Bhawan, Allahabad, short notes on the crop yields of U. K., China, and U. S. A., a note regarding experiments on mixed farming at the Indian Agricultural Research Institute and reprints of some bulletins,

etc., covering as much information on the points desired as available at this Institute, was furnished.

In October, 1946, the Director of Research, Travancore, sent information of the occurrence of 'Blister blight' of tea. On receipt of samples of diseased tea leaves, the Head of the Division of Mycology confirmed the diagnosis and a brief account of the history of the disease, and the measures to be adopted for its control and eradication was sent to the Director of Research, Travancore. The Mycologist, Indian Tea Association, has reported that a widespread outbreak of this disease appeared suddenly in the Surma Valley in 1937. It causes serious damage only in nurseries, young plants and heavily pruned bushes, when humidity is high and temperature low. Eradication of centres of infection formed by stray tea bushes, growing in cool humid places, in abandoned nurseries, etc., led to the total disappearance of the disease from the Surma Valley. As this was the first report received of the occurrence of the disease in South India, the Director of Agriculture, Madras, and the Secretary, United Planters Association of Southern India, were informed of its outbreak. The Indian Council of Agricultural Research having requested the Institute to prepare a scheme for tracing the history of the disease in South India, it has been suggested that a conference of Mycologists and Tea Planters interested in the subject may first be convened in Coonoor.

An outline for a Bureau of Plant Introduction to promote on a systematic basis the introduction of plants of economic benefit to the country to prepare plans for and carry out expeditions within India or outside as well as to maintain plant collections on a sufficiently wide scale, covering the whole range of plant materials which are capable of being exploited to the benefit of our national economy, was drawn and sent to the Indian Council of Agricultural Research.

Certain enquiries were received from the Director of Inspection, Ministry of Food, for information regarding the identity and poisonous properties, if any, of the weed seeds found in consignments of imported foodgrains. Some of the weed seeds were identified, but not all. The Department was informed accordingly and suggestions made for their removal by bulk screening at the port of entry, as apart from their possible deleterious effect on human beings there is a great danger of introduction of harmful weeds. This is possible where the weed seeds differ in size from the foodgrain. The weed seeds thus separated should be systematically destroyed. Information on the tolerance percentage of a weed seed '*Lolium temulentum*' in wheat was sent in response to an enquiry. Information was also given to the Deputy Public Health Commissioner on the toxic effects of *Agrostemma* weed found mixed with some imported wheat. The toxic substances in the seed are a saponin called githagin and another saponin, the poisonous effect of which is cumulative.

At the request of the Secretary, Indian Science Congress, a note describing this Institute and its research and other activities was prepared and supplied. At the same time a note was prepared summarizing progress in the agricultural sciences in India during the last 45 years. This note was supplied to Indian Council of Agricultural Research, New Delhi. In connection with the Asian Relations Conference, suggestions were made regarding the subjects on which co-operation between Asian countries with special reference to agriculture is possible. Adoption of the following ways and means was recommended to achieve the co-operation:—

- (i) Plant expeditions and exchange of plant materials;
- (ii) Co-ordinated system of soil classification to enable best use to be made of the results of research and experience of other countries concerning cropping systems, land use, soil fertility, erosion and reclamation and irrigation;
- (iii) Exchange of technical information;
- (iv) Personal contact;
- (v) Exchange of scientific personnel.

To implement the above, the formation of an organization with representatives from all participating countries was suggested.

Visits to United Kingdom

The Government of India nominated Dr. J. N. Mukherjee as a member of the Indian Scientific Delegations to the Empire Scientific Conference convened by the Royal Society, the British Commonwealth Scientific Official Conference and the Imperial Agricultural Bureaux Review Conference (as leader), held in the United Kingdom in June and July, 1946.

The object of the Royal Society's Conference was "to consider practical measures for promoting close collaboration between scientific people and organizations in the countries of the British Commonwealth and Empire and to make recommendations". Dr. J. N. Mukherjee contributed the following papers to the Royal Society Scientific Conference:—

- (i) An outline of the problem of land utilization and conservation in India;
- (ii) Position of soil survey and land classification in India;
- (iii) The productivity of Indian soils in relation to food supply.

The terms of reference of the official conference were "to consider the best means of ensuring the fullest possible collaboration between civil government scientific organizations of the Commonwealth and to make formal recommendations for the approval of the Governments represented". The Imperial Agricultural Bureaux Conference was arranged to take advantage of the presence of representatives of the various participating Governments and associate them with the enquiry that was being made into the working of the Bureaux organization.

In October, 1946, Major D. T. Brown, Head of the Division of Agricultural Engineering, was sent to visit the National Institute of Agricultural Engineering, Askham Bryan, England, to study its organization, equipment and work in connection with the organization of this new Division. Plans for the buildings of the Division have been drawn up and it is hoped that their erection and equipping will be started in the near future. While in the United Kingdom, Major Brown contacted several other institutions regarding design and equipment of greenhouses and some appliances.

Post-graduate Training

In connection with the reorganization of the courses of training at the Institute, a review was made of the purpose served by the Sugarcane Breeding Course and it was concluded that there was really a need for two distinct post-graduate courses relating to sugarcane, *viz.*, (a) a specialized course in Sugarcane Breeding and Genetics, and (b) a specialised course in Sugarcane Agronomy, as the agronomic aspects of sugarcane production involve several characteristic features for which specialized training is necessary together with a thorough training in agronomy, as applied to the other major crops. In addition to this, the need for a one-year course on sugarcane for giving supplementary training to persons deputed by provincial and State Governments, factories and Private Sugarcane Farms was felt. Accordingly, two new courses, *viz.*, a two-year Sugarcane Agronomy Course and a one-year course on Sugarcane have been introduced and the existing two-year Sugarcane Breeding course has been suitably revised.

Fifty-one students were admitted during the year, of which three left later. Thirty-seven second-year students were in residence. They were allotted problems covering the subjects of agronomy, agricultural chemistry and soil science, agricultural

botany, entomology and mycology. Details including a list of the theses submitted by the batch of students who completed their course in 1946 are given in Appendix II.

As the new hostel was not ready at the time of the admission of the new students, temporary arrangement was made for their accommodation in the Tibbia College hostels in Karol Bagh. During the disturbances of November 1946, it became necessary to evacuate them from Karol Bagh and the students of the Agricultural Division were temporarily transferred because of the shortage of the accommodation to the Agricultural Sub-station at Karnal; the remaining students were accommodated within the Institute area. The new hostel was completed later in the year and the students were able to occupy it on return from their summer vacation. The servants' quarters attached to the hostel, however, have not yet been built, resulting in some inconvenience. The construction of the gymnasium for the students has also not yet been undertaken. With the co-operation of members of the staff the students organized a very successful variety entertainment just before the summer vacation.

Publications

Fifty-one scientific papers and popular articles on scientific matters were published or in the press, during the year under review. A list of these is given in Appendix III.

Visitors

As in previous years, the Institute attracted quite a number of visitors. The Honourable Dr. Rajendra Prasad Member for Food and Agriculture, paid three visits; on one of these he was supplied with a note on the lines along which agricultural engineering science could assist the Indian cultivator. Other distinguished visitors included the Ministers of Agriculture from the United Provinces, the Central Provinces and Berar, Bengal, Assam and Orissa; the Iranian, Afghan and Nepalese delegations to the Asian Relations Conference. Several foreign delegates to the Indian Science Congress including the famous geneticist Dr. A. F. Blakeslee of Smith College, Northampton, Massachusetts, U. S. A., the Director of the Bureau of Plant Industry, Philippines, and Mr. C. E. McKnight of the American Embassy, New Delhi; Mr. Rathindra Nath Tagore, Shantiniketan; Dr. Shyma Prasad Mukherjee; and Mr. Jairamdas Daulatram.

Dr. A. B. Stewart who came out to India, at the invitation of the Indian Council of Agricultural Research, to survey and make recommendations in respect of work on soils and manures in this country, visited the Institute several times and held discussion with the Director and several members of the staff. He was given assistance in the preparation and copying of photographs, charts, etc.

II.—RESEARCH AND INVESTIGATIONS

1. Agronomy

Concept of Agronomy

Agronomy deals with the art and science of husbandry as also its economic and social aspects. It involves an integrated study of soils, crops and livestock in their climatic setting; of diseases and pests; and all other factors the control of which is of significance for husbandry. This integral aspect of husbandry does not seem to be well realised by many in this country. The sharp differentiation between the 'agricultural' and 'veterinary' organizations both in the provinces and at the Centre which prevails in India has led to a scientifically and practically unsound contrast

between 'crop husbandry' and 'animal husbandry' which are consequently being treated in more or less water-tight compartments. Climate, soils, vegetation and animals are ecologically inter-related and sound methods of conservation and exploitation of our soil, plant and animal resources must be based on the recognition of this inter-relationship. To mention an aspect, even in the crop production part of husbandry crops are being treated as individual crops without due regard to factors responsible for soil fertility especially those concerning its maintenance at an optimum level and to the balance between crops which deplete soil fertility and those which build or improve it. In effecting this balance, which generally involves the inclusion of legumes in the crop rotation (and also of grasses and mixtures of these) the distinction between so-called 'crop' and 'animal' husbandry becomes less important. The form which a sound system of husbandry will take in any tract depends on the climatic and soil conditions, topography, availability of water facilities, etc.; whether stress will be on cereals or cash crops, or pasture, or trees depend on the integral effect of these physical factors and also on economic and social factors. The picture of husbandry we now have is dominated by the production of individual crops. This is basically unsound both scientifically and economically.

Judging by the experience of other countries and present-day scientific knowledge, no substantial improvement in our low average yields of crops is likely until an integral approach is adopted in our experimental programmes as also in agricultural improvement and administration.

Not infrequently, however, one hears agronomy referred to in this country as though it meant nothing more than the cultural operations and manurial and varietal trials which are carried out on a farm.

Staff

In order that the Division of Agronomy may undertake on sound lines the elucidation of agronomic problems it is vital that it should be properly staffed and should possess technical talent in botany, agricultural chemistry, soil science, and the other sciences that are basically involved. A suitable set-up has been formulated and as the necessary staff is recruited scientific work in the Division, which has previously been handicapped by paucity of technical staff, should make better progress.

The Farm: area, past history, difficulties.—The total arable area of the farm attached to the Division is 380 acres which is used for the conduct of agronomic experiments, and for the production of (i) fodder and gram for the breeding herd of 287 heads and 64 work cattle, and (ii) pedigree seeds for distribution. At the time the Institute was transferred to New Delhi, a good deal of levelling work had to be done and large quantities of soil were scraped or dug out and moved to low-lying areas and to fill up pits and ditches. As was to be expected, this has resulted in considerable soil heterogeneities which are specially noticeable in certain parts of the farm. While high yields have been obtained from certain fields, in others the results have been poor in spite of heavy manuring. Due to this cause the original "Russell Experiment" initiated with the object of studying the relative values of nitrogen in organic and inorganic forms proved to be a failure; the new experiment on the same lines started three years ago has also suffered from the same difficulties. The persistence of low yields in spite of heavy manuring indicates that there must be other limiting factors which required to be resolved. No attempt was made to preserve the natural land surface wherever possible, nor was a thorough soil survey, which could have served as a basis for laying down manurial and other experiments, undertaken. This has now been begun and 30 acres have already been surveyed by the Division of Chemistry and Soil Science.

The difficulties occasioned by soil heterogeneity have been aggravated by continuous changes in the large number of manurial experiments which were laid down, with the result that it is difficult now to find any suitable large blocks with a uniform previous treatment or cropping history, in which to lay down new experiments.

An obstacle in the manurial experiments has been the heavy lodging of varieties of wheat, the cereal principally used in these experiments. This indicates that for these experiments we must use varieties which can stand up to intensive farming conditions so that the maximum production possible by proper manuring may be determined. A reference is made in the next section (Botany) to a new experiment that has been laid down to discover wheats suitable for different levels of soil fertility.

Systematic planned experiments in which the collaboration of other Divisions will be freely available are being introduced. The principal experiments which are still in their initial stages of progress are referred to below.

"Cultivator's Holdings".—Special mention must be made of an investigation which has recently been initiated which seeks to make an integrated approach to the solution of the problems of the industry of agriculture with special reference to the small-farmer. In our country, a pair of bullocks or buffaloes determines the smallest self-contained unit of farming and taking an acreage which can be considered to be characteristic of such a "unit farm" this investigation attempts to apply to it all the improvements which researches have proved or will prove to be possible, with a view to demonstrating to the peasant what overall increase in production and economic outturns science has made possible. The experiment has been started on three holdings of 7.5, 8.0 and 8 acres each and a system of mixed farming is followed. These are long-term experiments having the objective of building up permanently soil fertility by the adoption of the most suitable crop rotations and the use of grasses and legumes and by more efficient system of soil-crop management. It is also intended to see how far the produce of the land would support the cattle, and the crop rotation maintain the fertility of the land, and all operating together provide the farmer with food and his cash requirements. The intensity of green-manuring has been correlated with increased yields by previous experiments in the farm and these results will be made use of in the projected experiments.

Ley Farming

Under this system of farming, grasses in combination with legumes are grown in leys of two or three years' duration under suitable fertilizer treatments for the production of protein-rich fodder and for the accumulation of soil fertility for the succeeding cereal or cash crops. Experiments were started two years ago with a mixture of Rhodes grass and lucerne, and various fertilizer combinations of nitrogen, phosphates and potash. Nitrogenous fertilizer alone and in combination with phosphate and potash produced marked response from the grass, while phosphate increased the yield of lucerne. These experiments are also yet in their initial stages. A collection of grasses and of legumes is being gradually built up.

Experiments with nitrogenous manures and fertilizers

Reference has already been made to the new "Russell Experiment" for studying the relative values of nitrogen in organic and inorganic manures. The wheat crop during the last season was adversely affected by rust attack and the early onset of hot dry winds at the milk stage of the grain. The manured plots which promised to yield heavy crops lodged badly.

Phosphatic Manuring of Legumes

Perhaps the outstanding problem in Indian agriculture is the building up of soil fertility. The main object of the manurial experiments is to study how this can be done, in conjunction with suitable crop rotation in order that the overall production over a number of years for the same land can be maintained at an optimum level in terms of permanent agriculture. Experiments on the phosphatic manuring of legumes were started initially with *berseem* (Egyptian clover) and later with other *khari* (summer) and *rabi* (winter) legumes. The results obtained so far have shown that the effect of phosphates is (i) to increase the yield of legumes, whether grown for fodder or seed, (ii) to increase the nitrogen phosphate and calcium contents of the fodder, and (iii) to develop a stable type and a high degree of soil fertility for the succeeding cereal crops. Not all legumes, however, respond equally especially as regards the last factor. Herein comes the importance of choice of legumes suitable for this purpose as also for its use as fodder. This can only be done by systematic trial experiments located on different regions distinguished by soil and climatic conditions.

In a series of experiments on manuring of *berseem* started in 1940-41, several combinations of manures were tried to assess their effects on the yield of *berseem* fodder. Superphosphate alone and in combination with farmyard manure besides raising the yield and mineral contents of *berseem* also built up soil fertility which gave high yields for four succeeding wheat crops which were not manured. The permanent manurial experiments at Pusa (Bihar) also showed the significantly higher efficiency of legumes fed with phosphates in increasing soil fertility.

Experiments are also in progress to study the effect of different forms of phosphates, such as superphosphate, ammonium phosphate, bone-meal, and basic slag, on legumes grown in rotation with cereals. It has been seen that, with the exception of bone-meal, the response to these fertilizers has been very effective. The best results were obtained with ammonium phosphate and confirm previous observations that ammonium sulphate and super are better than super alone (in fact ammonium phosphate proved to be better than ammonium sulphate plus super), which seems to indicate the need for adding a dose of nitrogen in the initial stages of growth of the legumes. Even better responses were obtained with phosphates applied in combination with farmyard manure. Potash in combination with phosphates also gave encouraging results. In another experiment the effect of addition of ammonium sulphate to super on the growth of nodules was studied. Nodule formation was less pronounced when nitrogen was also added but the yield was greater though the difference was not statistically significant. These experiments will be continued.

Green-manuring

The practice of green-manuring has been found to increase the yields of crops grown in rotation and to maintain the productivity of the soil; for its success however due regard has been paid to its carbon to nitrogen ratio; suitable conditions of soil moisture must be provided and there must be an appropriate interval between the time of burying the green-manure crop and the sowing of the next crop. At the Farm, various leguminous crops, viz., sunnhemp, cowpeas, guar (*Cyamopsis psoraloides*), mung (*Phaseolus aureus*) were grown with and without fertilizers applied before sowing and also at the time of burying the "green-manuring" crops. The application of phosphate alone and with nitrogen in conjunction with green-manure gave encouraging results on the yields of wheat.

Fertilizer placement experiment

With the great shortage of fertilizers in the country, the question of their economic use is one of great importance. This experiment was started during the year under

report to test the comparative merits of placed and broadcast fertilizers, especially phosphates alone and in combinations with nitrogen and potash on the yield of legumes such as *guar* and pigeon-pea. Definite economy due to placement has been observed in this the first year of the experiment, when fertilizers were applied at half the rate for *guar*, and one-third or one-sixth the rate for pigeon-pea, as compared with the full dose for broadcasting. These experiments are also only in their initial stages.

Studies on Gram Wilt

Great damage is done to the gram crop every year by the "wilt" disease. The cause of this has not yet been satisfactorily elucidated nor are any efficient control measures known. A co-operative experiment has been initiated in which the Divisions of Agronomy, Chemistry and Soil Science, Mycology and Plant Pathology, and Botany are taking part. In the Agronomy Division, manurial and rotational experiments were laid down for the purpose. Two rotations (i) sorghum-gram and (ii) *guar*-gram have been adopted, with various combinations of nitrogen, P_2O_5 and K_2O .

Flood Water Farming Experiments

These experiments were started in 1941-42 to explore the possibilities of utilising surplus river water during the monsoon for raising food crop in areas deficient in rainfall. The fields are flooded during July, August, and September and it has been recorded in previous years that it ensures sufficient moisture in the soil for successfully maturing *rabi* crops such as wheat, barley, gram and oilseeds. During the year under report, however, the yields of barley and oilseeds in the field which received flooding were not so encouraging.

Grass and Legume Collections : Agrostology

A collection of indigenous and exotic grasses was started in 1941 with a view to testing their suitability for fodder and pasture. Among these there are many species that appear promising for purposes of ensiling and pasturage. A collection of clovers and other legumes has also been established for testing them as fodder and rotation crops. It is intended to enlarge the collection and the scope of studies and experiments on them individually and in mixtures so as to test their suitability as pastures, soil improvers and soil-builders and for control of erosion in different regions. A section of Agrostology is about to be initiated which will continue and expand the work on grasses and legumes, and that on ley-farming.

Cattle Breeding and Management

One of the important achievements of the Institute is the improvement in milch cattle. The Sabiwal dairy herd at New Delhi was started in 1904 when 14 cows and a bull were bought from the Montgomery district in the Punjab. The average milk yield of cows in milk per cow per day was then 5 lbs. The strength of the herd is now 287 head and the average milk yield per day about 20 lbs. Similar improvement has been effected in the Tharparkar herd which is maintained at the sub-station at Karnal. Although this is very satisfactory, it is necessary to continue work to see how much further improvement in the milk yield of Indian cattle is possible. 24,000 lbs. of milk per lactation have been obtained in some other countries as against about 12,000 lbs. so far recorded for the best Indian cows. The butter-fat content of Indian cattle is higher than that of western cattle and this must be kept in mind when making comparisons of milk production. Our cattle are also less susceptible to certain diseases. For these reasons there is some demand for bulls in other countries.

During the year, an improvement in milk yield was observed, the wet and overall averages being 20.9 and 15.1 lb. per head per day respectively as against 18.7 and 13.1 lb. recorded last year.

Handling, pre-milking and four-times-a-day milking were continued for the development of 'milk temperament'. A bulletin containing instructions for management of milch cattle of the two herds was issued.

A discussion was arranged with the Officer-in-charge of the Animal Nutrition Section of the Indian Veterinary Institute and Major Williamson, Animal Husbandry Commissioner, to consider the manner of co-operation that could best be effected between the animal and soil-plant aspects of 'trace' elements, this Institute being interested in the plant nutritional and soil aspects of such studies. It was agreed to put up a combined scheme of work to the Indian Council of Agricultural Research. The Indian Veterinary Research Institute has already put up a scheme.

Statistical Section

At present the main work of the section is the detailed analysis of the dairy records of the pedigree Sahiwal herd. A study of the variation in weekly averages of a number of cows in different lactations indicates that the cows reach their maximum yield in the eighth week in the first lactation, in the sixth week in the second lactation, and in the seventh week in the third lactation. In general, cows attain their maximum yield by the eighth week after which a downward trend begins. The milk yield increases with the lactations up to the third lactation. For want of complete data, subsequent lactations could not be studied.

The data relating to cows drying up, during the period 1938-46 which were studied separately, showed that cows attain their maximum yield by the ninth week and that usually fifth calvers gave the best yield.

Agricultural Sub-station, Karnal

The sub-station is situated about 75 miles north of Delhi on the Delhi-Ambala road. The total area of the sub-station is 2,154 acres with 1,267 acres under direct cultivation. The irrigation water is drawn from the Western Jumna Canal and the supply is on a rotational basis having a discharge of 7.3 cusecs which is hardly sufficient to meet the requirements of the sub-station.

Most of the agronomic experiments mentioned in the preceding paragraphs were repeated at Karnal and the results obtained were, in general, in close agreement with those reported before. The following additional investigations were carried out during the year under report.

(i) *Nitrogenous manuring experiments*.—Ammonium nitrate alone and with various percentages of T. N. T. were tested against ammonium sulphate on paddy and sugarcane. The results of the last three years have shown that on the basis of equal amounts of nitrogen, ammonium nitrate alone and in combinations with T. N. T. were as effective as sulphate of ammonia.

(ii) In an experiment to test the effect of the Chinese method of treating paddy seedlings in night-soil, the roots were dipped in a mixture of equal parts of night-soil, wood ashes and ordinary soil before planting them out. The underlying idea is to give a good start to the growing seedlings. The yields of paddy obtained by this treatment were better than those by other treatments, *viz.*, (i) farmyard manure mixed with wood ashes and ordinary soil and (ii) fertilizers to supply N, P_2O_5 and K_2O equivalent to nutrients contained in the former treatment.

A note of warning should, however, be given to this use of night-soil as it may lead to the spread of pathogenic organisms.

(iii) *Phosphatic manuring experiments*.—Various rotations of legumes with paddy are being followed to study the direct manuring of legumes, viz., *berseem*, gram and peas and their after-effects on paddy as against the direct manuring of paddy. In general, direct manuring of both the crops has shown marked response.

Botany

Early work

Improvement of crop plants through selection of pure types from heterogeneous local material and breeding was the main feature of the work of this Division in the first two to three decades following the organization of this Division in 1905. More fundamental studies of techniques of crop improvement were gradually taken up after the setting up of the agricultural departments in the provinces. It is now recognized that integrated research on related branches as cytogenetics, physiology, ecology, is capable of dealing more effectively with the problems of crop breeding, especially with reference to resistance to drought, diseases, etc.; the scientific problems involved in "fitting in" varieties to different climatic and soil conditions also require more attention than they have received hitherto in India and it is necessary that the botanist, soil scientist and agronomist work hand in hand in these subjects and not in isolation.

Recent Developments

A qualified cytogeneticist was appointed in 1938. It is now known that most of our cultivated crops have risen either as mutations from wild ancestors or as polyploids as a result of hybridisation between primary species and subsequent chromosome doubling. The origin of such plants in nature is limited by fortuitous circumstances such as overlapping of species, synchronisation of flowering and hybridisation, chance or deliberate introduction of a new species in the existing environment, etc. Nature, however, works on a vast scale of time and space. Investigations on the origin of cultivated crops, especially with the aid of newly-discovered tools, like colchicine and X-rays, Beta particles, neutrons, protons, etc., are expected to lead to a quicker synthesis of new and better crop varieties.

A section of Crop Physiology has been added in 1946 to the Division of Botany. Prior to this, physiological investigations on drought resistance and photo-periodism and vernalization were carried out by the Second Assistant Economic Botanist alone. Plant physiology is concerned with the investigation of the inter-relationships of the various life processes of the plant and the influence on these of its environment. A plant (or a crop) can express its maximum potentiality for growth (and yield) only when it is suitably adjusted to its environmental complex. It is evident that plant physiology can contribute, in no small measure, towards the understanding of this adjustment as well as its control in the direction dictated by practical or economic considerations. Physiological principles are involved in the nutrition of plants and in the correct choice and development of many items of agronomic practices. Such physiological properties of varieties, as earliness, drought and frost resistance, etc., are of importance in plant breeding.

Further expansion of this Division envisages organized attention to systematic botany, plant ecology and plant introduction and exploration for dealing with plant and crop surveys and assessing the collections of plant material for utilization in breeding.

Equipment

The difficulty of obtaining equipment for the laboratories continued to be acute. In spite of strenuous efforts in this direction only a few articles could be obtained.

Wheat Breeding

Work on various aspects of wheat improvement has all along been a feature of the Botany Division. Early success was obtained when the strains N.P. 4* and N.P. 12 were bred; these are still grown over hundreds of thousands of acres to-day. They were followed by a series of wheats outstanding amongst which are N.P. 52, N.P. 80-5, N.P. 101, N.P. 111, N.P. 114, N.P. 120, N.P. 125 and N.P. 165. In the earlier work, emphasis was laid on yield and quality of grain. In the current work, the question of disease resistance and standing power of the straw is receiving particular attention.

All the three rusts of wheat occur in India and constitute the most serious hazard to wheat production in the country. The recent epidemic of black rust which swept Central and Peninsular India last season is an instance. It is universally agreed that the most effective and economical way of doing so is to breed and grow resistant varieties. Breeding for rust resistance is, however, a complicated affair and must take into cognisance the existence of a large number of physiologic races within each of the three species.

Systematic breeding of rust-resistant varieties for the hills (these being the centres of permeation of the rusts according to Mehta), in collaboration with Dr. K. C. Mehta was started at the sub-station of the Institute at Simla, under a Scheme financed by the Indian Council of Agricultural Research. Wheat strains combining resistance to the Indian physiologic races of the three rusts respectively have been built up and work is in progress to unite resistance to all the three rusts. Present indications are promising.

Facilities for work on the same lines for the plains could not be provided yet. However, in recent years, artificial rust epidemics have been created in the plots at New Delhi and tests conducted for adult resistance. Tests for resistance to the smut diseases have also been conducted as a collaborate project of the Divisions of Botany and Mycology.

Wheat Trials

During the last season some of the more promising strains bred recently at the Indian Agricultural Research Institute were sent to 15 places in Northern India for trials. Some wheats have yielded fairly well in spite of the severe rust epidemic already alluded to. Further details are given in the Report of the Division.

Some interesting experiments on the acclimatisation of wheat varieties are being conducted in Jaipur in co-operation with the State Department of Agriculture. It is proposed to continue the study.

An experiment on the response of different wheat varieties to different levels of manuring has been undertaken. Six varietal treatments (five varieties and the sixth treatment being the mixture of the five varieties) were tested against three levels of fertility and the control, which did not include any manure. This year's observations show that in general the higher the level of fertilizers, the greater the vigour, plant height and tiller number. A heavy incidence of both rust and lodging vitiated the experiment regarding grain yield. The experiment will be continued using more suitable varieties.

* N.P.=New Pusa. Formerly, the strains were designated as "Pusa" or "Imperial Pusa" types.

Study of the influence of environment on Quantitative and Qualitative Characters.

19 out of 200 varieties grown in previous years at Delhi, Pusa and Coimbatore appeared to show marked reaction to changes in environment. They are being grown at the above three places and also at Simla. This is a long-term project.

Potato Breeding

Potato breeding was seriously taken up in India in 1935 under a scheme drawn up by this Institute, and financed by the Indian Council of Agricultural Research in 1935. At Simla where conditions are favourable for flowering and seed-setting, a large number of new varieties of hybrid origin has been evolved. Trials conducted in the hills with the co-operation of the Provincial Departments of Agriculture indicate that Hybrid Nos. 2, 5, 12 and 19 are promising. Varieties resistant to the late blight disease common in the Simla hills have also been evolved. As far as the plains are concerned, only preliminary testing has so far been done.

The Simla Sub-station has been used for the maintenance of valuable collections of wheats and potatoes and also for other experimental purposes and if the Sub-station passes to the proposed Central Potato Research Institute as is anticipated, the Indian Agricultural Research Institute will be put to considerable difficulty.

Hybrid Vigour

Maize is a crop which has been largely neglected in the past. Experiments on inbreeding and hybrid vigour were taken up under a scheme for the improvement of the Maize crop in India, financed by the Indian Council of Agricultural Research. A number of commercial varieties, inbreds, single and double crosses imported from foreign countries, were under study. Some single and double crosses from Australia were found to be promising.

Breeding for wilt-resistance and rust-resistance in pigeon-peas and linseed respectively and for high nicotine in tobacco was continued.

Production of Chimeras

A series of grafting experiments involving the potato, tomato, *Datura*, *N. glauca*, etc., was in progress for the past two years, in an attempt to secure, if possible, in a vegetatively-propagated crop like the potato, chimeral varieties which would resist certain diseases because a thin outer layer of a resistant variety covered the susceptible but otherwise desirable variety.

Cytogenetics

The lines of work in progress include the study and utilization of different methods of plant breeding like polyploidy, interspecific hybridization and mutations for crop improvement. Work was also undertaken to evolve cytotaxonomic systems of classification of crop plants and a tentative system of classification has already been worked out for the oleiferous *Brassicae*.

The colchicine-induced autopolyploids of a number of crop plants were under study with a view to evolving superior tetraploid strains. Although the tetraploids show an increased seed size, their reduced seed fertility rendered them unsuitable for direct commercial use. Selection for fertility and intervarietal hybridization was, therefore, resorted to. In *Brassica* selection of fertile plants year after year led to an increased fertility of the tetraploid strains. No appreciable improvement in yield was, however, apparent in the tetraploids of chilli (*Capsicum annum*) and gram (*Cicer arietinum*). Progenies from intervarietal crosses in the autotetraploid strains of *Brassica*, chilli and til (*Sesamum orientale*) were under observation.

Work was continued on the utilization of the wild Indian species, *S. prostratum*, for breeding strains of *til* resistant to a virus disease and to a caterpillar pest. Work on the utilization of wild species of brinjal, tomatoes, etc., was also continued.

Studies on the inheritance of the "dyad" condition of pollen grains, "clumped pollen" character and male sterility in *toria* and female sterility in *taramira* (*Eruca sativa*) were also in progress.

Crop Physiology

The non-irrigated area under wheat in India is far greater than the irrigated and the yield level under the former conditions is on the whole lower. Investigations were, therefore, undertaken to study the physiological principles that were of interest in work on breeding wheat for drought-resistance. From a comparative trial of a large collection of exotic and Indian varieties of wheat grown under dry and irrigated conditions, it was concluded that temperature during the period of ripening of the grain had, among all the factors, a predominant effect on yield. Varieties which flowered late in the season and mature their grain during the period of rising temperature, in April and May, developed shrivelled grain and thus gave low yields. The tests of resistance to artificial drought (in pots) at (a) the tillering stage, (b) the shooting stage and (c) at both stages indicated no measurable difference of the varieties at stage (a); in (b) and (c) yield was considerably reduced in the late varieties, whereas in the early ones the effect was much less.

Highly saline soils are found in some wheat areas. Experiments showed that in the soils made saline before sowing, germination as well as yield was reduced, whereas in the soil made saline later the growth was little affected. Seeds pre-treated with common salt solution showed better germination in the saline soil. Seeds of N.P. 4 wheat, when pre-treated with a strong solution of common salt, gave lower yield than the control in a field trial. In previous seasons seeds pre-treated with water alone had given higher yields under non-irrigated conditions.

Experiments involving nine wheat varieties indicate that the hastening of flowering was related to the amount of light. Under suitable combinations of treatments the ordinarily late varieties flowered early, the grains ripened during the period of low temperature and yielded as well as the early varieties. These experiments also point to the predominant effect of temperature on yield.

The discovery of plant hormones has provided a very useful tool for influencing the course of plant growth and development. At low concentrations plant hormones stimulate certain plant activities and at high concentrations they inhibit the same. Some of them and related chemical compounds have proved useful also as selective weedkillers. Systematic work on plant hormones is contemplated.

A long-term experiment was undertaken to ascertain from the physiological point of view the limits of crop production and the factors that set these limits under a given environment.

The aetiology of reddening of the leaves of *shaftal* (*Trifolium resupinatum*) was under study. Preliminary work indicated that the anthocyanin pigments probably developed as a result of nitrogen starvation during early stages and after flowering and fruiting.

The effect of a maize crop on the yield of wheat which followed it was taken up for study. Pot experiments showed that wheat sown in the soil in which maize had been grown during *kharif* lagged behind the control in the early stages but made up later and yielded as well as the control. The experiment will be continued.

Plant Introduction and Exploration

A scheme for starting work on a small scale for plant introduction and plant exploration, financed by the Indian Council of Agricultural Research, came into

operation last year. Exotic material received during the year mainly from the U.S.A., Canada, England, Australia, Africa, Kenya, China, Philippines, etc., consisted of varieties of cereals, fodder grasses, wild relatives of wheat, legumes such as soyabeans, *Lespedeza Pueraria*, lupins, various kinds of fodder and vegetable beans, tomatoes, brinjal, cinchona, castor, flax and a few ornamental and hedge plants. A part of this material was supplied to certain provinces and states for trial under different soil and climatic conditions. The imported material and the indigenous material collected during the surveys was grown at Delhi and relevant observations taken.

Small areas in the plains of U.P. and C.P. and in the Himalayan ranges were surveyed and seeds and plant specimens of important plants of Leguminosae, Malvaceae, Solanaceae, Graminae, and other families were collected. The collection of leguminous seeds consisted of species of *Phaseolus Dolichos*, *Medicago*, *Trigonella*, *Lespedeza*, *Desmodium*, *Crotalaria*, *Indigofera*, *Alysicarpus*, etc. Seeds were also collected of certain wild Himalayan medicinal plants.

Performance tests of vegetables

At the request of the Agricultural Development Commissioner with the Government of India, 512 samples of 22 kinds of vegetables received from the U.S.A. and from Indian growers were tested for germination, purity and field performance.

Seed distribution

There was considerable demand for New Pusa strains of crop plants evolved by the Institute. The demand for wheat seeds was particularly heavy especially for N.P. 52 which did well during the recent rust epidemic. Unfortunately it was possible to meet only a very small portion of the requirements. The matter was receiving examination with a view to increasing foundation stocks of pure seeds for supply to Provincial and State Departments of Agriculture.

Sugarcane Research

Plant collections

The success achieved in the breeding of economic types in the sugarcane is due mainly to the available initial materials especially of the related wild species, *Saccharum spontaneum*. Though there has been no organized expedition so far for making systematic collection from the various parts of India and elsewhere, sufficient materials had accumulated during the course of many years of breeding work since 1914. These include many varieties of (a) *Saccharum officinarum*, (b) *Saccharum Barberi* and *Saccharum sinense* (Northern India canes), (c) *Saccharum spontaneum* and (d) a few types of the related genera like *Narenga*, *Sclerostachya*, wild Sorghums and *Erianthus*. Amongst these, *Saccharum spontaneum* has the widest range of distribution extending from the slopes of the Himalayas to the tropics of Sumatra and Java. From the study of the miscellaneous small collections of this species which have been made it is found that it is distinguished by having many eco-types with distinct chromosomal variations. So far only two tropical types of *Saccharum spontaneum* had been used both at Coimbatore and in Java for breeding. An expedition for the exhaustive collection and the study of the different forms of *Saccharum spontaneum* and related plants from the various parts of India is being organized and is financed by the Indian Central Sugarcane Committee. This is expected to widen the scope of sugarcane breeding work by enabling the introduction of hardy qualities as resistance to frost, drought and disease in the future commercial canes.

The available collections are now maintained under tropical conditions of Coimbatore and sub-tropical conditions at Karnal. The maintenance of the Live

Herbarium at Karnal is especially important to study the responses of the parent materials to the conditions obtaining in the sub-tropical belt.

Breeding technique

Sugarcane breeding is now systematised, starting from mass hybridisation and ending with the distribution of Coimbatore canes to the Provincial Sugarcane Stations. However, further improvements in the technique during the various stages are found to be necessary for introducing greater precision on a scientific basis. For instance, in the nursery stage seeds are sown in the local country-made earthenware pans and the germination and growth at this stage of the material are found to be very uneven with the consequence of the possible loss of useful genetic material. It is, therefore, proposed to substitute these pans by glazed uniform pottery. Similarly in the matter of selection of seedlings from the "1st ground" to the "2nd ground" nursery, selection covering the whole of the plot has to be done instead of restricting only to a particular portion of the plot. Test plots have also to be laid out on a statistical basis which means more area and with the proposed expansion of sugarcane breeding station, it is expected that greater precision will be introduced by following up-to-date statistical methods and greater attention to improving of cultural operations and of soil conditions.

Improved cane varieties

During the year, 15 promising seedlings were selected finally from the test plots as "Co. canes" and distributed for trials to the various provincial sugarcane stations in India. Though nearly more than 400 canes (Co. canes) have been sent out from Coimbatore during the course of the last 3 decades so far only a few of these like Cos. 213, 285, 312, 313, 419, 421 and 453 have entered into the varietal composition of the canes grown in India. This is because the conditions obtaining at Coimbatore are quite unlike the varied climatic and soil conditions prevailing in the sub-tropical belt of India where more than 80 per cent. of the cane area in India is located.

Under the essential limitation that breeding work has to be restricted at Coimbatore because of the favourable conditions for hybridisation work, the distribution of a greater number of seedlings every year to the provincial stations for trial, would, it is expected, give a greater choice for selection of better varieties suitable to the different tracts. This aspect of the problem is now recognised and will be put into operation after the expansion of the Coimbatore Station and the co-ordination of the work of the different provincial stations through the Indian Central Sugarcane Committee.

The recognition of suitable parents for transmitting useful characters in the progeny is important for sugarcane breeding, especially in view of the complicated genetic make-up of the cane materials which are either complex polyploids or hybrids. Experimental crosses, however, greatly facilitate the selection of such parents and it was found that the cross Co. 508 $\times$ Co. 301 gave early maturing types with a solid core. Co. 449 is yet another parent for introducing early maturity and Co. 534 and 557 for eliminating pith in the seedlings. Among many other crosses made during the year, some are intended to meet the growing demand of the provinces for chewing canes and also a few for evolving fodder types.

Cytogenetical studies

The study of the behaviour of chromosomes in interspecific and intergeneric hybrids has provided explanations for certain distinguishing features of sugarcane as compared to other crops, especially in the breeding aspects. Such studies on the fundamental scientific issues are expected to lead to the understanding of the processes by which the indigenous canes of India (Northern Indian canes) have originated in nature. These canes (*S. barberi* and *S. sinense*) are considered to be polyploid complex hybrids between

the noble cane *S. officinarum* and *S. spontaneum*. Studies are now in progress to trace the origin of *S. officinarum*. Work done during the year indicates that this species is a composite of two fundamental species each with a basic chromosome number $x=5$ and one of these is present also in a related grass belonging to the different genus, *Sclerostachya*. These studies have a practical bearing on the synthesis of better economic forms from fundamental species when these are identified.

Physiological studies

Investigations of the conditions governing the flowering of sugarcane are in progress with the object of bringing into breeding certain non-flowering canes as well as to delay or hasten flowering to suit the hybridisation programme. By manipulating factors like photoperiod, manuring and irrigation, it has been found possible to induce flowering in a number of useful non-flowering varieties and adjust the time of flowering in a number of late and early flowering varieties. The study of chemical composition of cane varieties in relation to flowering habit is also in progress.

Chemistry

The Division is now organized into the following Sections:—

1. General Agricultural Chemistry.
2. Soil Chemistry.
3. Soil Fertility.
4. Micronutrient Elements.
5. Soil Survey.
6. Soil Physics.
7. Physical Chemistry.
8. Soil Microbiology.
9. Organic Chemistry including Plant Chemistry.
10. Biochemistry.

The requisite laboratory space was allocated for the work of these Sections and consequential additions and alterations were made in the equipment.

Equipment

Several rooms in this Division were refitted to conform to the changes in its organization. As mentioned earlier, in this report, some useful equipment was purchased from the Calcutta University. Apart from this, no major purchases of apparatus were found possible, although orders were placed with a number of firms; small additions were, however, made including a Lumatron photo-electric colorimeter.

Manurial experiments (Delhi)

Reference has been made under Agronomy to a large number of manurial experiments conducted at the Institute Farm. These are being conducted jointly with the collaboration of the Division of Chemistry and Soil Science. Investigations have been in progress on the relative values of nitrogen in green manure, farmyard manure, compost, oilcake and ammonium sulphate; estimates have been made of the recovery of nitrogen by the crop and the changes in the moisture, ammonia (exchangeable) and nitrate contents of the soils of the different plots. The data indicate that at the time of sowing wheat there is present in the soil an appreciable amount of nitrate formed from the application of the manures, especially in those plots to which oilcakes were applied. After the harvest of wheat, however, the nitrate in all the plots was negligible.

Increase in the nitrogen content has been observed in all the crops grown in this experiment as a result of the application of the nitrogenous fertilizers and manures. The recoveries of nitrogen were better from sulphate of ammonia or oilcakes than in other forms.

Studies are also in progress on the effect of phosphatic fertilizers on legumes in building up soil fertility and on the rate curves of the solubility of soil phosphates in different solvents. Phosphatic fertilizers increase the phosphate content of all the summer and winter legumes studied, namely cow-peas and *guar* in summer and berseem, gram, peas, *shaftal* and *senji* in winter. Total yields, however, are markedly greater only for *berseem* and to a lesser extent for the other winter legumes, but generally speaking not so for the summer legumes.

Permanent Manurial Experiments at Pusa (Bihar)

Not much attention has been paid in the past to the chemical aspects of the Permanent Manurial Experiments at Pusa, one series of which has run for over forty years. Investigations on these were taken up during the year under report by the Division of Chemistry and Soil Science. Proposals for thorough investigation are now in course of being worked out in consultation with the Divisions of Agronomy and Botany.

Soil Fertility : Indicator Plant Studies

The importance of studying the complex problem of soil fertility in all its aspects has already been stressed. Besides the studies on phosphatic manuring of legumes in relation to building up soil fertility which have already been referred to, investigations have been undertaken using the indicator plant method of determining mineral deficiencies in soils. It has been observed that *berseem* and *shaftal* showed reddening of leaves in some of the unmanured plots in the farm. Preliminary experiments show that the reddening of *berseem* is probably connected with phosphate deficiency. Further experiments are in progress with these and some other legumes.

Foliar Diagnosis

This year's analyses on leaf samples collected from the wheat plots in the New Permanent Manurial Series at Pusa indicated association between yield and the intensity of nutrition as well as the proportion of N and P_2O_5 in the NPK unit. The highest yield was obtained in the fertilizer treatment which included N and P_2O_5 . Further work is in progress.

Micronutrient Studies

Investigations on the effect of nitrogenous and phosphatic manuring on leaf-colour and thickness in tobacco were continued on plot and pot experiments. It seems that the attack of the leaf-curl disease was less with plants having a composition showing a higher P/N ratio. Effect of micronutrient elements is being studied.

Under a scheme financed by the Indian Council of Agricultural Research, the role played by micronutrient elements in the deficiency diseases of citrus, namely "mottle leaf", "die-back" and "premature fruit shedding" is under investigation. A deficiency of manganese has been found to be definitely associated with all these diseases. In the case of mottle leaf, a significant deficiency of zinc and in die-back, of boron has been observed in addition to manganese.

The co-operative investigations on the wilt disease of gram have been already referred to. In this connection, samples of healthy and diseased plants were collected and analysed for the following elements: boron, manganese, iron, molybdenum, calcium, magnesium, phosphorus and potassium. It seems several diseases are prevalent with

different symptoms of which the incidence of "bronzing" is greatest and plants showing symptoms of this have been studied. There is a marked deficiency of phosphate and an indication of deficiencies of boron, manganese and of excess of silica, iron and molybdenum. Further work is in progress.

The analytical methods of determining boron, zinc and copper were standardized and the analysis of contents of cobalt and molybdenum in plant tissues and soils undertaken.

Soil Survey

The question of a co-ordinated scheme for carrying out soil surveys in India based on modern concepts of soil science has been discussed off and on for a long time. Excepting a small number of cases mostly resulting from the initiative of enthusiastic workers in different parts of the country, very little progress has yet been made in this field. A scheme for an all-India Soil Survey was discussed about 12 years ago by the Soils and Crops Wing of the Board of Agriculture. Later, a proposal for an all-India Soil Survey was discussed by the Indian Council of Agricultural Research as a result of some recommendations made by Sir John Russell in his report to the Council.

Under a scheme initiated in December 1942, and financed by the Indian Council of Agricultural Research, all available experimental data on Indian soils, published and unpublished, have been collected and collated, and a report giving a detailed account of the available information has been submitted to the Indian Council of Agricultural Research. Soil maps have also been prepared based on these data.

The scheme has terminated and the men engaged in this work were absorbed in the regular establishment of the Institute for carrying out such surveys in which the Institute is interested and to provide for training of students in soil survey. A geographer with suitable training has been added to the staff for carrying out topographical surveys, soil mapping and cartographic work. Soil surveys are still being carried out sporadically in different places. But very little progress has yet been made regarding the question of a co-ordinated all-India Soil Survey. Dr. A. B. Stewart, who was invited by Government to report on "soil fertility investigations in India with special reference to manuring" has made proposals regarding rapid reconnaissance soil surveys as also detailed soil surveys in his report, which is now under consideration by the Indian Council of Agricultural Research. As pointed out by Dr. Stewart in his report, certain remarks of the Royal Commission on Indian Agriculture to the effect that soil surveys were not necessary had been mainly responsible for sufficient attention not having been paid to this vitally important subject. Climate, soil and organisms form an intimate ecological association. With our teeming population and the rate at which it is increasing, the optimum utilisation of our soil resources consistent with the conservation of the soil material and of its fertility must occupy the foremost place in our agricultural planning. Much more intensive and systematic attention to soil surveys and to the conditions of erosion is an obvious and urgent necessity. Dr. Shuhart has reported on the work of erosion control being carried out in the country. This report is also under consideration by the Indian Council of Agricultural Research. Trained soil surveyors with an adequate knowledge of soil science and agronomic practices will be required in fair numbers for all these types of work and it is hoped that the Institute will develop further its activities in this direction. It should be realised that soil surveyors require specialised training.

One sometimes notices a misunderstanding of the purposes of soil survey. It is not so much the genetic classification of soils which is of practical interest as the fact that the use of a soil can be better based on information obtained by the study of its profile. The profile basis of soil study has come to stay as it affords more complete information vital to plant growth than a mere examination of the top nine inches of the

soil, which is also liable to great and rapid changes as a result of treatments. A study of the penetration of roots down the profile in itself gives valuable information, so also variations in texture, presence of salts, lime nodules and other concretionary materials, existence of pans or compact layers, etc. These are all of great practical significance.

It is unfortunate that in quite a number of cases experimental farms have not been located after due consideration of the suitability of the site. It is also not known in many cases to what extent the soils of the farm are representative of the soils of the area in which it is located. The number of regions which have markedly different soil and climatic conditions in India revealed by the available data, however meagre they are, is quite large. Much larger number of stations with well planned programmes of experimental work and adequate equipment will require to be established throughout the country.

The soil survey of the Institute Farm and of the Karnal Sub-station has been undertaken. At New Delhi, 26 profiles in 30 acres were examined and about 60 soil samples collected for analyses. At Karnal, 14 profiles have been examined in 115 acres and 22 soil samples collected for analyses.

A rapid reconnaissance survey of about 200 acres of land near Ajmer was undertaken at the request of the Agricultural Officer, Ajmer-Merwara. The area is proposed to be irrigated by the construction of a reservoir in the Gaurikund Hills near Saradhana. A similar survey of nearly 500 acres at the Bhadrak Farm at Lucknow was undertaken at the request of the Vice-Chairman, Indian Council of Agricultural Research, to find out the suitability of the area for sugarcane cultivation.

A similar survey of nearly 3,000 acres was carried out at Jubbulpore near the Khamaria Ordnance Factory at the request of the Animal Husbandry Commissioner, Indian Council of Agricultural Research, to determine the suitability of the area for establishing a Central Cattle Breeding Farm.

A very rapid reconnaissance soil survey of the Rann of Cutch was carried out at the request of the North Western Railway with the object of assessing the suitability of the area for agricultural purposes.

Physical Chemistry

Studies of colloidal constituents of soils isolated from different horizons of a black cotton soil are in progress. These include determinations of base exchange capacity and exchangeable bases, electro-chemical properties of hydrogen clays, part played by aluminium in exchange acidity and electro-chemical properties of humic acid sols isolated from the above soils.

Soil Physics

The investigations on the effect of surface colour controlled by putting coloured mulches on the soils on plant growth were continued.

Investigations on pF permeability and pore space of soils of the Institute Farm are in progress.

Plant Chemistry

Varieties of tobacco from all over India were examined for their nicotine content with a view to selecting varieties of high nicotine content for use in preparing insecticides. The project is being carried out in collaboration with the Divisions of Botany and Entomology.

Samples of pyrethrum from different pyrethrum-growing centres in India were also examined for Pyrethrum I and II.

Chemical changes in flue-curing of tobacco

The chemical changes during flue-curing of tobacco were studied under a scheme financed by the Indian Council of Agricultural Research (this has recently been taken over by the Indian Central Tobacco Committee). It was found that while no marked differences from grade to grade were shown by the chemical analyses, the leaves could be divided into two broad categories: (a) grades 1 to 4, characterised by high ash content, high soluble solids, high reducing and total sugar and low nitrogen, and (b) grade 5, "light green" and "dark green", characterised by low values of the substances just indicated. It thus appears that it is not easy to distinguish between leaf grades on the basis of the above chemical constituents alone.

A study of the composition of tobacco leaf and soil samples collected from areas known to grow tobacco of good and poor quality respectively was also taken up. The results indicated that leaf from the good areas is characterised by high sugar content and low nitrogen while the reverse holds true for the leaf from the poor areas.

Entomology

Laboratory

An addition was made to the Entomological Laboratory and one large laboratory room, one lecture room and four small rooms were constructed during the year. One of the rooms in the older portion of the laboratory was, however, given on loan to the Plant Protection and Quarantine Organization, this being in addition to the accommodation already occupied by that organization.

Equipment

Owing to difficulties which have already been pointed out, no major article of equipment could be added.

Insect collection and taxonomic studies

During the past four decades, a large and valuable collection of Indian insects identified and named with the help of well-known authorities in various parts of the world has been built up by the Division. In addition to numerous unnamed insects, the collection contains over 25,000 named species. During the year under review 200 specimens comprising 20 species of Diptera and 6 specimens comprising 3 species of Rhynchota were registered and card-catalogued. Twenty species were received back from the Imperial Institute of Entomology, London, after identification. An additional 119 species of insects received as donation including 111 from the Forest Entomologist, Dehra Dun, were also added. The Institute donated specimens of 550 species to various institutions in India including the Plant Protection and Quarantine Organization.

Taxonomic studies and studies of life-histories of insects of economic importance have always been a feature of the work of the Division and are being continued. Particular attention is being given to the study of Indian parasitic Hymenoptera particularly Ichneumonidae Diptera of agricultural importance; and Rhynchota particularly Aphididae and Isoptera.

Population studies

Population studies of insects are important as affording an idea of the biological balance and the climatic factors affecting it. Data from carefully planned experiments would enable epidemics of injurious insects to be forecast, so that control measures can be adopted in time. Detailed knowledge of the biological balance is useful in many ways, as for instance, in the discovery of selective insecticides and the protection of beneficial insects. Insect ecology which comprehends all such aspects has so far

received very little attention in India. A scheme for research on insect populations, with special reference to the spotted boll-worms of cotton, has, however, been in progress at the Institute since the last five years or so, but it has not been possible to achieve much progress so far. A member of the staff of the Institute has been devoting himself specially to such studies.

The soil as a factor in the perpetuation and perennation of pests and diseases, and the chemical aspects thereof also deserve investigation.

Biological control of Sugarcane Pests

The experiments on the control of the stem-borer of sugarcane, *Argyria sticticraspis*, by using the parasite *Trichogramma*, were continued. The work was mainly done at Cuttack. The results obtained during 1946 showed that as a result of the successive liberations of the parasite, there was a steady increase of parasitisation in the blocks which had been so treated, and ultimately 100 per cent. parasitisation was obtained indicating that the stem-borer can be controlled quite well by timely liberations of the parasite. During December last, eight blocks of five acres each were planted at Banki and parasite liberation and studies of borer-egg parasitisation and borer populations have been in progress.

The *Pyrilla* conservation experiments referred to in the last report were repeated at Karnal. The data analysed so far show that the conservation of parasites is a fairly effective measure against the *Pyrilla* pest.

Insect vectors of virus diseases

Work on the insect vectors of virus diseases has been confined mainly to the transmission of the serious leaf-curl disease of tobacco and it has been shown that the white-fly *Bemisia tabaci* is the vector concerned. Transmission experiments repeated during the year under report confirmed that the leaf-curl disease could be transmitted from tobacco to papaya and from papaya back to tobacco by means of the same white-fly species.

A survey was also conducted of the sucking insects on the potato crop.

Pests of stored foodstuffs

The conservation of stored foodstuffs has acquired even greater importance in view of the critical food situation in most countries of the world and particularly in India. The investigations which have been in progress in the Division of entomology have been concerned mainly with pests of *jowar*, pulses and dried fruits. Studies of 24 varieties of *jowar* from different parts of India show distinct differences in their susceptibility to four important pests of the crop. None was resistant to all the pests but JS 20 showed a high degree of resistance to three of them. The effect of methyl bromide and ethylene dichloride as fumigants against the *jowar* pests was also investigated.

Studies of the damage caused by bruchids to pulses were continued. The fumigants, methyl bromide, ethylene dichloride and carbon bisulphide have been examined. The influence of DDT, 666 and various inert dusts and vegetable oils on the breeding of bruchids was also under investigation. Carbon bisulphide was very effective in killing adults and grubs but was almost ineffective against the eggs, whereas methyl bromide was effective against all the stages of the pest. Ethylene dichloride was found to possess little penetrating power. A number of these substances has been found to restrict the breeding of bruchids very considerably. Suitable dosages have been worked out which are given in the report of the Division of Entomology. A distinction has to be made in the selection of pesticides for the control of pests of stored grain required for use as seed and as food. Cumulative poisons such as mercurials should be avoided for the latter purpose unless it has been established that the quantities involved are of no matter.

Insecticides

The use of poisons for the destruction of insect pests is a common practice in modern agriculture. The insecticides recommended for controlling the pests of crops must, however, be cheap, effective, easily applied, if they are to be adopted by the small cultivator. They should not also be harmful to man and livestock or to beneficial insects. There is thus a wide field of research on these subjects. Synthesis and trial of new chemicals are being pursued with vigour in many countries. In addition to these, the possibilities of employing indigenous plant materials and other substances require to be actively investigated. The value of many plant products such as pyrethrin, nicotine, rotenone is well established as they have properties complementary to or not possessed by the synthetic chemicals. Often a mixture of both types is helpful. Steps for the development of suitable plant products should, therefore, be taken simultaneously with that of synthetic chemicals.

Studies carried out during the year with the collaboration of the Division of Chemistry aimed at investigating the insecticidal properties of opium and opium marc and tobacco. Dusting of opium (treated with 5 per cent. acetic acid) at 40 lbs. per acre on cow-peas brought a reduction of 67.6 per cent. on the fourth day and 89.2 per cent. on the ninth day of the population of *Empoasca devastans*; a second application brought about a still higher mortality in the pest. Opium smoke obtained by burning marc gave encouraging results when used against *Tribolium castaneum* and *Corcyra cephalonica*.

Tobacco decoction made from varieties of *Nicotiana rustica* grown in the Division of Botany gave a maximum kill of 90 per cent. when used against full-grown larvae of *C. cephalonica*. The introduction and breeding of tobacco varieties with high yields of nicotine is a matter of some importance and attention is being paid to this by the Division of Botany.

Besides the substances mentioned, it is proposed to study the usefulness of rotenone, pyrethrum, D.D.T. and Gammaxane. The method of preparation of the insecticide for use and the manner of its application also require research and experimental trials.

Need for better spraying and dusting appliances

Unless insecticides which in laboratory-scale experiments have given very satisfactory results can be successfully and cheaply applied on a field scale under the peasant's conditions, they will be of little economic value. At present spraying and dusting appliances are imported from abroad, or are Indian-made copies of them. It is therefore proposed to study the possibilities of these as also to design new types specially for use under Indian conditions as a co-operative project of the Divisions of Agricultural Engineering and Entomology.

Advisory

A large number of requests are received every year for specimens identification of insects and control measures of pests and these are dealt with as thoroughly as possible. During the year, a note on the control of sugarcane pests was furnished to the Indian Council of Agricultural Research for circulation to the interested Provinces and States.

Assistance to Plant Protection and Quarantine Organization

The Institute has assisted the newly-established Plant Protection and Quarantine Organization by providing accommodation in the Entomology and Mycology Laboratories at considerable inconvenience to itself, by permitting free access to and use of the insect collections and mycological herbaria, and the Library.

Mycology and Plant Pathology

Buildings

A new wing was added to the Mycological Laboratory to house the Herbarium and to provide additional laboratory accommodation. In actual practice, however, the Division of Mycology did not benefit by the increase in accommodation as the greater portion of it was taken on loan by the Plant Protection and Quarantine Organization. A large insect-proof glasshouse, 60' x 50', which was urgently required for virus studies was also completed.

Equipment

Orders were placed for a large number of items of equipment but most of this was not available for immediate supply.

Herbarium and Fungi Culture Collection

The *Herbarium Cryptogamae Indiae Orientalis* of the Division containing specimens of Indian fungi which was started at the time of E. J. Butler is well known and now contains about 16,000 specimens. By the end of 1920, nearly 1,800 species had been collected, identified and several of them studied in detail. Since then a further large number has been added and studied. During the year 113 specimens were supplied to teaching institutions and research laboratories. Specimens of Indian fungi, on an exchange basis, were also supplied to the University of Wyoming, U. S. A., Mycological Herbarium, Madison, U. S. A. and the Naturhistoriska Riksmuseet, Botaniska Afdelningen, Stockholm, Sweden.

The Indian fungi culture collection was maintained. The total number of live fungi and bacteria in the collection is 691. The British Commonwealth Scientific Official Conference held last year drew attention to the importance of microbiology in many branches of pure and applied science and recommended that no existing collections of type cultures should be dispersed and that the formation of new collections should be encouraged wherever there is a definite need for them. The Conference also recommended that a Central Commonwealth Organization should be established for the maintenance of collections of type cultures of micro-organisms, and that the attention of the United Nations Organization should be drawn to the desirability of establishing an international body of similar type to extend co-ordination to the international field. In view of the importance of the subject, action was taken to extend the collection. Investigations were in progress during the year to see if routine transfers of the various fungi could be done at longer intervals than at present, with a view to economise time and labour. It was found that certain fungi belonging to the *Ascomycetes*, *Basidiomycetes* and *Deuteromycetes* remained viable for at least eight months if the usual cotton plug of the culture tube was replaced by a cellophane seal.

Fungal Diseases of Crops

The chief function of the Division has been the study of diseases of crop plants caused by parasitic fungi, with a view to devising measures for control. A good deal of attention was paid to the testing for disease resistance of strains of crop plants evolved in the Division of Botany, especially in respect of the smut diseases of wheat, the wilt disease of pigeon-peas and the late-blight disease of potatoes.

Gram Wilt

As stated earlier in this report, the wilt disease (or diseases) of gram causes serious havoc to this crop, and a co-operative scheme of work was drawn up to investigate it.

Earlier work on the mycological aspects of the disease gave results which were confusing; a number of organisms were isolated from diseased plants and these plants did not all show the same pathologic symptoms, nor did all of them reveal the presence of a pathogenic organism.

During the year a careful study was made of symptoms shown by diseased plants in the field, isolations of organisms were made from such plants, and healthy plants were artificially inoculated with those organisms which appeared to be consistently associated with wilted plants. The results are given in detail in the report of the Division of Mycology.

Late Blight and Early Blight of Potatoes

The testing of potato varieties bred at the Simla Sub-station was continued; out of 103 stocks tested, 22 completely failed to take infection. Further work was done on the *Phytophthora* causing tuber-rot of potatoes at Kufri; this fungus has now been confirmed to be a new species which has been named as *P. himalayensis* Dastur. Preliminary studies were carried out with the Early Blight fungus.

Pigeon-pea Wilt

Twenty-eight varieties of pigeon-pea including new strains bred in the Division of Botany were tested for resistance to *Fusarium redum* Butl.; of these five failed to take infection. In an experiment in which two lots of soil were used, one sterilised and the other unsterilised, for testing the disease resistance of two varieties, it was interesting to observe a much higher percentage of infection in the plants grown in the sterilised soil.

Sugarcane Diseases

Isolations made from diseased canes during the red-rot epidemic in the United Provinces last season revealed that a light-coloured, highly-sporing type of the causal organism was predominant. Varieties of cane were tested for resistance to both red-rot and smut. While a number of them, including Co. 356, 419, 421 and 453 were found to be more or less resistant to the former disease, none of the important commercial varieties was observed to be resistant to smut.

Wheat Rust

The Division of Mycology has hitherto not paid much attention to the wheat rusts, work on which has been done almost entirely by Dr. K. C. Mehta of Agra. The black rust epidemic last season, however, showed how important it was to the food position in this country to control the ravages due to this source and to immediately undertake the studies of rust dissemination, epiphytotics and physiologic races to provide the necessary scientific data for devising control measures. As mentioned earlier, a scheme was drawn up for co-ordinated work on the problem throughout the wheat-growing areas of the country and at the Indian Agricultural Research Institute, and the Division of Mycology will assist in the co-ordination of the work on the disease aspects.

Aeroscope Studies

A study of air-borne spores in the Institute area has been undertaken and slides were examined every week from December, 1946; spores of *Helminthosporium* and *Alternaria* were caught on slides exposed during March to May. A uredoscope of *Puccinia graminis* was first trapped on a slide in the week ending 9th December, 1946.

Fungicides

It is obvious that fungicides must be both cheap and effective if they are to find favour with the Indian peasant, whose financial resources are exceedingly slender; there is, therefore, a need for testing our indigenous materials from this view point. A beginning was made, on a small-scale, for the study of this problem, and plants growing locally were tested in the laboratory for their fungicidal properties. Preliminary tests during the year showed that leaf extract of *mendhi* (*Lawsonia alba*) and bark extract of *amalthas* (*Cassia fistula*) have fungicidal and fungistatic action against *Helminthosporium halodes* and *Alternaria solani*.

Virus Studies

One of the most striking developments in modern times in the domain of plant diseases has been the study of viruses which are now recognized to be responsible for some of the most important diseases of crop and garden plants. They are of special importance in solanaceous crops such as potatoes, tobacco and tomato. In Europe and America, great advances in the technique of virus study have been made. In India, however, the subject has been comparatively neglected and what little has been done has been achieved in the absence (with one or two exceptions) of proper insect-proof glass-houses and modern equipment. Studies on the physical and chemical properties of viruses require costly equipment. This should, however, be made available at least at this Central Research Institute for the benefit of the whole country.

The work on plant viruses and the diseases caused by them which has been done at the Indian Agricultural Research Institute has been restricted mainly to the potato crop, and has followed three chief lines, *viz.*, (i) the identification of virus diseases affecting the potato crop, (ii) the setting-up of an organization for producing and multiplying certified potato seed, and (iii) the working of a scheme which aimed at making available immediately by a process of roguing-out of all severely diseased plants stocks of seed potatoes which while not disease-free, would be appreciably less contaminated by the more destructive virus disease than the ordinary seed available in the trade. Under the first head, viruses namely, *Solanum Virus* 1, 2, 3, 4, 8, 9 and 14 have been identified and studies on the mode of transmission of the first-named are in progress. Under the second head, the results have been rather disappointing and only a very small quantity of virus-free seed of one variety (Darjeeling Red Round) has been produced. This nucleus will be multiplied as rapidly as possible. It should be mentioned however, that work has been carried out under difficulties. For example, at the high altitude station at Kufri in Patiala State no glass-house was provided and there have been difficulties about securing sufficient isolation of the experimental plots from the surrounding potato-growing area and also in obtaining the necessary accommodation for laboratory and residential purposes.

The survey of potato-growing areas to determine areas of low virus infection where healthy seed might be multiplied for certification purposes has not led to any definite results and the survey has suffered from the failure to associate an entomologist with the work. Another drawback has been the lack of arrangement for growing initially disease-free potatoes in the various areas under survey to study the spread of virus diseases; observations made on cultivators' crop the initial virus infection of which was unknown naturally could not supply sufficiently reliable data.

Under the third head, crops specially grown for the purpose at Karnal and Hapur were kept under inspection and 2,780 maunds of seed potatoes were supplied to the Provinces and States in 1946. The yield from this seed was reported to be satisfactory. During the year under report the scheme was partially reorganized and fields showing a low incidence of disease in Bihar and U. P. were selected. From these 3,595 maunds of tubers of a size suitable for use as seed were purchased and stored.

It is expected that except for certain fundamental aspects, the potato work referred to above which has partly been financed by the Indian Council of Agricultural Research will be taken over by the Central Potato Research Institute which is under contemplation.

Work has also been in progress on the virus diseases of certain other crop and garden plants. The virus causing the mosaic disease of sunnhemp was successfully crystallised.

Bacteria

The study of bacteria in relation to plant diseases has not received much attention hitherto in India. In the reorganized and expanded programme of work of the Institute adequate provision has been made for work on this subject in the Divisions of Mycology and Chemistry.

Plant Quarantine

The setting up of a Plant Protection and Quarantine Organization by the Government of India must be welcomed as a measure that has been long over-due. It is, however, important that the work which the organization is to do should be clearly defined to prevent wasteful duplication. The main function of the organization should obviously be to take steps to enforce such legislation as is enacted for purposes of plant protection and quarantine. The research aspects of problems relating to plant diseases and pests must be left to the existing research institutes, both of the Central and Provincial Governments, and to the Universities.

Agricultural Engineering

General

The work of the Division of Agricultural Engineering is still in the initial stages of its development and research work has been on a restricted scale. A number of new machine tools, hand tools and other equipment have been procured but the construction of even the first portion of the proposed machine shop has not yet been taken up.

Main Objectives

One of the most important objectives of the Division is to foster agricultural mechanisation to the extent that this is necessary to increase the operative efficiency of the Indian peasant, keeping in mind the special aspects of Indian agriculture such as the small size of the fields. The main lines of work which are under contemplation are (a) the improvement and modification of existing implements and methods, (b) the design of new and better implements and machinery which could be operated by bullocks or by simple power-driven prime movers and (c) the adoption, after modification to suit our conditions, of new implements and machinery both of foreign and local make.

Water Pumps

Water is the most important single limiting factor in Indian agriculture and the invention of a portable pump capable of lifting a fair quantity of water from either tank, well or river would be a boon. In this connection a promising type of pump has been obtained from abroad and plans are in hand for making the necessary modifications to enable it to be tested and tried under varying conditions and for its operation by bullock drive or motor power.

Kans eradication

The Head of the Division continued to act as a member and secretary of the *Kans* Control Committee set up by the Government of India and the experiments at Bhopal were continued. An area of about 100 acres of very heavily *kans*-infested land which had completely gone out of cultivation was ploughed in 1946 between 11th May and 17th June and divided into four blocks to which the following main initial treatments were given: (a) deep ploughing alone, (b) deep ploughing twice with an interval of one month, (c) deep ploughing followed by picking of the *kans* rhizomes and beaming, and (d) ploughing and beaming only. In each of the blocks six different crop treatments were employed, each crop treatment being replicated six times.

The subsequent crops raised were very satisfactory. Detailed results have not yet been received.

Experiments with the Jeep

Experiments were carried out on the Institute Farm to investigate the possibilities of using jeeps for agricultural operations. The general conclusion arrived at as a result of these tests was that provided certain modifications were made, the jeep could serve as a utility vehicle for very light field operations and general transportation work.

III.—GENERAL ADMINISTRATION

Charge

Dr. J. N. Mukherjee continued to hold the post of Director of the Institute.

Dr. B. P. Pal, Head of the Division of Botany continued to hold the post of Assistant Director throughout the year.

Staff

The Divisions of Botany, Agriculture, Mycology, Agricultural Engineering remained throughout the year under the charge of Dr. B. P. Pal, Mr. C. H. Parr, Mr. J. F. Dastur, Major D. T. Brown respectively. Dr. S. V. Desai who was holding charge of the Division of Soil Science and Agricultural Chemistry in addition to his duties as Second Agricultural Chemist proceeded on leave to U. S. A. from 15th August, 1946 and resumed charge of the Division on return from leave on the forenoon of 25th April, 1947. During his absence Dr. R. H. Siddiqi, Organic Chemist, held charge of the current duties of the Head of the Division of Chemistry in addition to those of his own. Dr. Taskhir Ahmad, Second Entomologist remained in charge of the Entomological Division up to 26th December, 1946 when he proceeded on leave. On return from leave on 22nd January, 1947 he was appointed to officiate as Head of the Division of Entomology. The Sugarcane Station, Coimbatore remained throughout the year under the charge of Mr. N. L. Dutt. A list of the Gazetted staff together with such changes as occurred in the different Divisions is given in Appendix I.

The following Research Schemes financed by the Indian Central Sugarcane Committee and the Indian Council of Agricultural Research as noted against them continued functioning at the Institute:—

Schemes financed by the Indian Central Sugarcane Committee.

- (i) Sugarcane Sub-station, Karnal.
- (ii) Scheme for Research on Diseases of Sugarcane.
- (iii) Scheme for Research on Biological Control of Sugarcane Pests.

- (iv) Scheme for Research on Physiology of Sugarcane.
- (v) Scheme for additional staff for the Sugarcane Station, Coimbatore.

Schemes financed by the Indian Council of Agricultural Research.

- (i) Scheme for Research on Potato Breeding in Northern India.
- (ii) Wheat Breeding Scheme.
- (iii) Tobacco Breeding Sub-station, Guntur.
- (iv) Scheme for Research on storage of Jowar.
- (v) All-India Soil Survey Scheme.
- (vi) Seed Potato Certification Scheme.
- (vii) Seed Potato Multiplication Scheme.
- (viii) Scheme for Research on storage of Pulses.
- (ix) Scheme for the standardization of technique of the fumigation of imported fruits for the control of codling moth.
- (x) Scheme for Research into the properties of colloid soil constituents.
- (xi) Scheme for Research on Minor Trace Elements in Indian Soils and Plant Nutrition.
- (xii) Scheme for Introduction of Economic Plants.
- (xiii) Scheme for the Improvement of Maize Crop in India.
- (xiv) School of Research in Entomology.

Training

90 applications were received in all for admission to the Post-Graduate and Plant Protection Courses beginning from October, 1946. 51 were selected for admission; 15 in Agriculture, 10 in Botany, 1 in Sugarcane Breeding, 6 in Chemistry, 9 in Entomology, 5 in Mycology and 5 for Plant Protection (one year course). 13 students completed the two-year Post-Graduate courses during the year and were awarded the Institute Diploma; 6 in Botany, 1 in Chemistry, 3 in Entomology, 1 in Mycology and 2 in Sugarcane Breeding. Four students completed the one-year course in Plant Protection. Facilities were afforded to a number of short course students and honorary research workers as shown in Appendix II. Besides, 4 Research Fellows (who will be paid Rs. 150 per mensem) will be employed every year from among the associates of the Institute to carry on independent research under the supervision of the Heads of Divisions. A beginning has been made by appointing 3 such research fellows during the year under report.

Library

The total number of publications received in the library both by way of exchange and by purchase was 1,828. 4,182 books were issued out on loan during the year, of which 650 were sent out to the scientific workers in the Provinces and Universities.

6,968 visitors made use of the Reading Room and consulted 56,397 books during the year.

IV.—ACCOUNTS

The total expenditure of the Institute and its sub-stations at Karnal, Coimbatore and Pusa during the financial year ended March, 1947 amounted to Rs. 14,08,441. A further expenditure of Rs. 33,487 was also incurred on account of the undermentioned

three temporary schemes sanctioned by the Government of India which were financed from the Central Revenues.

	Rs.
General expenditure of the Institute including the Office of the Director.	
Irrigation, Power Supply, Gas Plant and Estate Establishment	3,41,029
Division of Agriculture	2,49,495
Division of Mycology	81,501
Division of Entomology	78,158
Division of Soil Science and Agricultural Chemistry	1,58,287
Division of Botany	94,170
Statistician	9,330
Division of Agricultural Economics	
Division of Agricultural Engineering	71,708
Sugarcane Sub-station, Coimbatore	1,23,849
Total Expert Staff and Directorate	12,07,527

Experimental Farms.

Agricultural Sub-station, Karnal	1,64,640
Botanical Sub-station, Pusa	36,174
Total Experimental Farms	2,00,914

Grand Total of Expenditure 14,08,441

Schemes financed by the Government of India.

Kans Control Scheme	28,213
Central Seed Testing Station	3,104
Icorya Purchase Scheme	2,170
TOTAL	33,487

The expenditure of the various research schemes financed by the Indian Council of Agricultural Research and the Indian Central Sugarcane Committee amounted to Rs. 2,03,928 and Rs. 61,637 respectively as shown below:—

Schemes financed by the Indian Council of Agricultural Research.

	Rs.
Potato and Wheat Breeding Sub-station, Simla	48,761
Tobacco Breeding Sub-station, Guntur	28,304
Scheme for Research on storage of Jowar	4,177
Seed Potato Certification Scheme	18,304
Seed Potato Multiplication Scheme	74,297
Scheme for Research on storage of Pulses	6,974
Scheme for All-India Soil Survey	982
Scheme for Research into the properties of colloid soil constituents	4,135
Scheme for Research on Minor or trace Elements in Indian Soils and Plant Nutrition	3,140
Scheme for introduction of Economic Plants	2,086
Scheme for the improvement of Maize crop in India	2,963
School of Research in Entomology	5,357
Scheme for fumigation of imported fruits for control of codling moth	4,448
TOTAL	2,03,928

Schemes financed by the Indian Central Sugarcane Committee.

	Rs.
Sugarcane Sub-station, Karnal	12,513
Scheme for Research on Diseases of Sugarcane	8,410
Scheme for Research on Biological Control of Sugarcane Pests	24,191
Scheme for Research on Physiology of Sugarcane	13,419
Scheme for additional staff for the Sugarcane Breeding Station, Coimbatore	3,104
TOTAL	61,637

The receipts of the Institute and its different Sub-stations amounted to:—

	Rs.
Main Institute	1,05,063
Sugarcane Sub-station, Coimbatore	12,533
Agricultural Sub-station, Karnal	1,18,526*
Botanical Sub-station, Pusa	4,332
TOTAL	2,40,454

* *Vide* Income and Expenditure Accounts reproduced below.

Income and Expenditure Account for the year ended March, 1947.
Income.

	Rs.
1. By sale of Dairy Produce	55,742
2. By sale of Farm Produce	44,231
3. Miscellaneous receipts	2,233
4. Live-stock	16,320
TOTAL	1,18,526

Expenditure.

1. Pay of Officers and Establishment	37,475
2. Leave Salary	...
3. Travelling Allowance	733
4. Dearness Allowance	14,204
5. Feed of Dairy Cattle, etc.	17,574
6. Workshop	2,411
7. Production of grain and fodder	52,761
8. Fuel, light, water, etc.	5,599
9. Miscellaneous Contingencies	3,590
10. Repairs to Plant and Machinery	8,113
11. Petty construction and repairs	180
12. Purchase of cattle, land and machinery	...
13. Equipment	31,973
TOTAL	1,74,613

REPORT OF THE DIVISION OF AGRICULTURE.

I. AGRONOMY.

(a) DIVISION OF AGRICULTURE, NEW DELHI.

Season and Crops.

The characteristic weather feature of the year 1946-47 was deficient rainfall during the monsoon and winter months of the year. The total rainfall during the year was 15.49 inches as against the normal of 22.19 inches and 30.16 inches during the preceding year. An excess rainfall of 2.43 inches during June enabled *kharif* crops to be sown in time. They, however, suffered from drought in the subsequent months and frequent irrigations had to be applied to ensure full growth of the crops. September was rather hot and dry. Except for heavy and extensive lodging in sugarcane and maize, caused by a shower of 2.14 inches on the 15th followed by strong wind, crops were above the average in stand. The high September temperatures affected the germination of berseem.

Total rainfall received during *rabi* season was 2.39 inches only and that also was not well distributed. Owing to deficient rainfall in October and absence in November, *rabi* crops received presowing irrigations. Minimum temperatures remained below normal during the winter months. At the shooting stage dry conditions again made imperative a resort to irrigation. Late-sown crops particularly suffered at this stage. Peculiar weather conditions during March affected all the *rabi* crops adversely. Maximum temperatures were above normal. The rainfall of 0.82 inches recorded on 13th March was preceded and accompanied by a strong wind with an average velocity of 35-40 miles per hour which caused lodging in all the cereals. Manured crops suffered more than unmanured ones. Towards the end of March and during April, at the milky stage of the grain hot and dry winds caused premature ripening of the late-sown cereals, the yields of which were adversely affected. Besides, the incidence of rust was rather severe which further depressed yields (*see* Table I).

Seed Supply.

About 9,025 lbs. of different types of cowpeas, maize, sannhemp, barley, soyabeans, peas, wheat, gram, oats and berseem seeds were supplied to meet local and outside demands from Delhi stock. Sugarcane seed weighing about 2,240 mds. was distributed locally to cultivators.

Work on Sugarcane.

An area of 6.4 acres was under sugarcane. The Division of Entomology studied incidence of insect pests on an experimental crop of 1.5 acres. Resistance of various varieties to mosaic disease was studied by the Division of Mycology.

Eleven new Coimbatore canes, Co 634 to Co 644 were planted in the nursery. Of these Co 634, Co 635, Co 636, Co 642 and Co 644 appeared more promising than others. These have been put under multiplication. Sixty-three old varieties were under observation. Besides the standard varieties, Co 617, Co 618, Co 621 and Co 622 exhibited superior performance among the varieties received in recent years.

Nitrogenous Manuring Experiments.

Comparison in field experiment of the relative values of nitrogen in organic and inorganic manures, estimating the recovery of nitrogen by the crop and of the changes.

brought about in the soil.—Comparative results of the past three years (Russell Experiment No. 2 started in 1944-45) are reported below:—

TABLE I.

Yield of wheat type N.P. 165 in maunds per acre.

Treatment per acre.	Yields of Grain.		
	1944-45.	1945-46.	1946-47.
A. Sannhemp (G. M.)	28.12	20.72	13.88
B. Cowpeas „	31.19	20.23	15.53
C. Rape Cake @ 40 lbs. N	31.03	22.43	16.44
D. Castor Cake „ „	32.29	20.54	16.31
E. F. Y. M. „ „	33.43	19.96	14.48
F. Leaf Compost „ „	29.08	20.45	18.98
G. Amm. Sulphate „	26.72	22.21	17.67
H. No manure (control)	27.25	19.31	17.62
Critical difference (5%)	5.18	2.51	3.59

The crop was adversely affected by rust and onset of early dry hot winds whereby the yields were reduced. In the preceding two years the control generally yielded less than the manurial treatments. But in the year under report lodging reduced the yield of most of the manured plots which generally had heavier stand than the no manure treatment.

Phosphate Manuring of Legumes and its after effects.

This series of experiments started in 1940-41, was expanded considerably in order to follow up and further clarify the results obtained earlier. The experimental results of the year under report have confirmed the striking effect of phosphate in increasing the outturn of legumes and their nutritive value and raising up the basic soil fertility of the land for the succeeding crops. The results of the various experiments are summarised as under:—

(i) *Berseem Manurial Experiment No. 1.*—In this experiment, started in 1940-41 several combinations of manures were tried to assess their effect on the yield of berseem fodder superphosphate alone and in combination with farmyard manure, besides raising the yield of berseem, raised up the basic soil fertility of the land. Thus the results of 1946-47 experiment from two rotations, (a) fallow-wheat and (b) cowpeas-wheat, without the further application of phosphate, confirm the results of the past three years that in plots which earlier were under berseem and treated with superphosphate, wheat yields had been significantly higher than no manure or plots receiving nitrogen, whether ornagic or inorganic, without phosphate.

(ii) *Berseem Manurial Experiment No. 2.*—This experiment was started in 1941-42 on the same lines as the above with much smaller doses of phosphate, namely 16, 32

and 64 lbs. P205, than were used in Experiment No. 1. The response to the application was marked at 64 lbs. P205 level per acre, both in the fodder outturn of berseem and the residual effect on the yield of wheat. During the year under report the wheat yield differences in the pre-berseem phosphate treated plots over the untreated ones were not significant.

(iii) *Efficiency of different forms of phosphates applied alone and in combination with other manure.*—In this experiment phosphate manures ammonium phosphate, superphosphate, bonemeal and basic slag alone and in combination with the basal farmyard manure, sannhemp, green manured, sulphate of potash and no basic manure were compared to test the efficiency of different forms of phosphate for invigorating growth of berseem and building up basic soil fertility for wheat. The experiment was started in 1944-45 and during the year under report ammonium sulphate was substituted for sannhemp (G.M.). In the *khariif* 1946 maize was grown to test the fertility built up by two previous experimental crops of berseem. Though the yield was highest in plots receiving ammonium phosphate followed by those treated with superphosphate and basic slag, the differences were not significant. The basal manurial treatment of potash in combination with different forms of phosphate gave higher yield of maize than the other basal manurial treatments.

Berseem succeeded maize in *rabi* 1946-47 and was under experiment as in the preceding seasons except that basic slag was not applied. The fodder outturn results confirmed the previous results that plots receiving ammonium phosphate, superphosphate and basic slag (residual) in order exhibited better response than no phosphate treatment. The combination of farmyard manure basal treatment with dressed phosphate generally gave higher yields of berseem than phosphate applied alone.

(iv) *Phosphate manuring of berseem with and without basal manuring with farmyard manure or green manure.*—In the experiment started in 1944-45 berseem was manured with different forms of phosphates for one year only under three basal series namely, (a) sannhemp green-manured, (b) farmyard manure at 10 tons per acre and (c) no manure (control). That was followed by unmanured crops of maize or wheat in 1945-46 and maize-berseem in 1946-47. The unmanured maize and wheat crops (1945-46), grown after manured berseem, yielded higher under phosphate treatments than without phosphate.

Again maize of *khariif* 1946, generally indicated higher yields in phosphate-treated plots, the differences between the treated and untreated plots being not significant.

In *rabi* 1946-47 berseem followed maize to see whether bonemeal applied in 1944-45, which hitherto had not indicated any response on different crops, would show its value on the most responsive crop of berseem. The yields of berseem revealed firstly that bonemeal was still ineffective, secondly that slightly higher yields were obtained from plots manured with other forms of phosphates than the 'no manure' control plots and lastly farmyard manure basal treatment still showed higher yields than the other two series. These differences, however, were indicative rather than significant. Thus in general, from the past three years' results the conclusion arrived at is that berseem manured once with phosphates can build up soil fertility which is effective for two succeeding cereal crops.

(v) *Phosphate manuring of berseem at different levels in combination with different doses of potash.*—The object of the experiment is to study the differential response of phosphates in combination with different levels of potash on the yields of berseem and residual effect on three succeeding crops of maize-wheat-maize. Berseem yields cut in *rabi* 1946-47 have shown that phosphates, ammonium phosphate and superphosphate, were effective when applied at 160 lbs. P205 per acre. Potash at 80 lbs. K20 per acre in combination with phosphates gave significant yields. Potash alone was ineffective. Maize crop has now been sown for study of residual effect.

(vi) *Effect of phosphate, potash, lime and nitrogen in different combinations on kharif legumes and aftereffects on wheat.*—The experiment was started during the year under report with soyabeans, cowpeas, guar and mung as legume crops to which manurial treatments were given and their residual response was noted on wheat crop. The manurial treatments consisted of N, P, K, PK, NP, NK and NPK with and without lime. The response of the legume crops to these manures were not significant, though the phosphate indicated slight increases in yields. The aftereffects of the fertilizers on wheat were also not significant.

(vii) *Direct and indirect manuring of maize in rotation with rabi legumes.*—The purpose of the experiment, started in rabi 1946-47 on winter legumes, is to study the response of each of them to application of phosphates and the residual fertility they build up for the succeeding cereal crops. The winter legumes included in the experiment were berseem (standard), senji, methra, peas and gram. Peas and gram were grown for seed and others for fodder. The crops were manured with N, NP, PK, and NPK. All crops except gram showed significantly higher yields in plots manured with phosphates alone or in combination with other fertilizers than the untreated control. The gram crop suffered badly from high incidence of late wilt. Its results were, therefore, not consistent under the manurial treatments.

A study of root nodules was carried out and it was observed that phosphate alone or in combination with potash encouraged nodulation while phosphate in combination with nitrogen had a slightly depressing effect.

(viii) *Phosphate manuring of berseem (New series I and II).*—These experiments were laid down in rabi 1946-47 with a view to obtaining confirmatory data regarding the beneficial aftereffects of phosphatic manuring of berseem on the subsequent wheat crop. Berseem was manured with P, PK, PN, PNK and F.Y.M. Phosphate was applied at two levels of 60 and 120 lbs. P205 per acre. The doses of nitrogen and potash were 30 and 80 lbs. per acre respectively. The rotation of the 1st series is berseem-guar-wheat and of the 2nd series berseem-fallow-wheat. Phosphate treated plots of berseem, in series I, did not indicate significant differences in fodder outturn. In series II phosphates alone and in combination with potash produced significantly higher yields over 'no manure' control.

(ix) *Phosphate manuring of berseem (New series III).*—The objective of this experiment is to study how far berseem treated with phosphates and followed by guar for three years would build up soil fertility as judged by the subsequent yields of unmanured wheat and maize. In this experiment, started in rabi 1946-47, phosphate at 50 and 100 lbs. P205 per acre singly and each in combination with 80 lbs. K2O per acre were applied to berseem. The yield differences amongst the treatment were not significant.

Soil and crop analyses are made for the uptake of N, P, K and Ca. The analytical data are reported by the Chemistry Division.

(x) *Experiment on the placement of phosphatic fertilizers to early pigeonpea intercropped with guar and soyabean.*—This experiment was started in kharif 1946 to test the comparative merit of placement of phosphatic fertilizer to broadcasting it. The fertilizer treatments were: P, NP and NPK. These fertilizers were placed at full and half rates of those adopted for broadcasting in the case of intercrops of soyabeans and guar. For pigeonpeas the doses dressed were $\frac{1}{3}$ rd and $\frac{1}{6}$ th of those used for broadcasting. Pigeonpea was sown in rows 6 ft. and $4\frac{1}{2}$ ft. apart. In between these rows, two of soyabeans and one of guar were sown for fodder. The placed fertilizers were drilled into the soil through a *pora* and seed was sown by *kera*. The fertilizers were thus placed about 2—3 inches below the seed.

Definite economy by placement of fertilizers was indicated by higher yields of guar fodder with half the quantity of placed fertilizer compared to full quantity broadcast. In this respect the effect of phosphate was marked. As soyabeans crop was smothered by vigorous growth of pigeonpea, and 'guar' it did not give conclusive results. In the case of pigeonpea (U.P. 132) where $\frac{1}{2}$ rd and $\frac{1}{6}$ th of the doses were compared against full dose for broadcasting, the yields in the former two cases were as good as in the control treatment. The yield of pigeonpea was higher with 6 ft. than with $4\frac{1}{2}$ ft. spacing between the rows.

Green-manuring Experiments.

(i) *Residual effect of fertilizers applied to sannhemp and cowpeas on the yields of wheat.*—The experiment was laid down in 1945-46. The fertilizers applied were N, P and Ca and their combination. After wheat harvested in *rabi* 1945-46, maize and wheat were grown in the same plots during the year under report to study the residual effect. In the sannhemp green manure series NP and bonemeal and sulphur treatments significantly increased the yield of maize (1946) over the green manure treatment alone. In the cowpeas green manured series the yield differences amongst the treatments were not statistically significant.

Wheat type C. 228 following maize in *rabi* 1946-47, gave almost similar responses in yields under different treatments. The residual effects of NP and of bonemeal alone in conjunction with sannhemp green manured were significant over the green manure treatment. The yields of wheat were very poor on account of late sowing and early onset of dry hot weather.

(ii) *Green-manuring experiment with sannhemp grown in situ or brought from outside.*—This experiment was started in 1945-46 at the instance of the Department of Agriculture, Government of India. The specific object of the experiment was to see whether sannhemp grown in another field such as grown on waste land on either side of the railway lines and incorporated in the fields of the cultivator direct or after composting would prove as effective for green manuring purposes as that grown *in situ*. Different fertilizers used were N, P and NP. Phosphate was applied at the time of burying the green manure and nitrogen was top dressed when wheat was sown.

Amongst the methods used for green manuring there were no significant differences in the yields of wheat. Specific differences in outturn of wheat due to phosphate alone or in combination with nitrogen were observed. The interactions, however, were not significant.

(iii) *Green-manuring experiment with mung, guar and cowpeas with placed and broadcast fertilizers applied to the green-manuring crops.*—The experiment was started during the year under report. Artificial fertilizers such as P, NP and NPK were applied, both by placement and broadcasting to the green manuring crops when they were sown. For studies on availability of nutrients wheat type C. 518 was grown in *rabi* 1946-47 as the indicator crop. Phosphate treated plots though indicated better yields, the differences in yields due to various treatments were not significant.

(iv) *Green-manuring experiment with indigo.*—Indigo seethe as a waste product was commonly employed as beneficial organic manure. The present experiment, with a view to ascertaining the value of indigo as green manure crop, was started this year. Indigo was sown in the month of April, 1946 with P, Ca, PK, PCa, and PKCa in combination with and without nitrogen. The crop was buried in August. Wheat C. 518 was sown in *rabi* 1946-47. Manured plots had a heavy stand and lodged badly on 13th March, 1947. The lodging obliterated the apparent differences amongst the treatments and the results were not significant.

Flood Water Farming Experiments.

These experiments were started in 1941-42 to explore the possibilities of utilizing monsoon and surplus supplies of river water for raising food crops. In the previous years it was observed that when large quantities of water were applied in August and September there was a temporary reduction in soil fertility due to leaching of nitrates to deeper zones which had an adverse effect on crop growth in the early stages. During the year under report, this difficulty was overcome by distributing the basic requirement of flood water over July, August and September, imitating the optimum conditions of a well distributed monsoon. The yields of different crops grown in *rabi* 1946-47 are given below:

TABLE II.

Yields in maunds per acre.

Treatment per acre.	Series.	Rabi Crops.			
		Wheat.	Barley.	Gram.	Toria.
No manure	Flooded.	18.32	10.02	14.22	9.17
	Rainfed.	3.62	10.59	9.48	11.92
Ammonium Sulphate 40 lbs. N. . . .	Flooded.	24.00	12.38	13.53	10.62
	Rainfed.	5.52	9.74	9.29	18.11
Ammophos 40 lbs. N. + „ P205.	Flooded.	23.68	12.80	13.40	13.45
	Rainfed.	4.25	14.02	10.62	17.73

The results indicate firstly that wheat and gram respond to extra conserved moisture, secondly *toria* yields were depressed by flood water farming and lastly barley under no manure treatment gave similar yields with 40 lbs. nitrogenous application as ammonium sulphate the yield was increased but with ammonium phosphate application the yield by flooding was somewhat less than rainfed conditions. The yield differences were significant in the case of wheat, gram and *toria*.

Ley Farming or Alternate Husbandry.

In the experiment started last year with a mixture of Rhodes grass and lucerne under different fertilizer treatments for the production of protein rich fodder for 2—3 years and building up soil fertility for the succeeding food crops, two cuttings of fodder were taken during the year under report. Fodder yields of Rhodes grass confirm the preceding year's results, namely, that nitrogenous fertilizers alone and in combination with phosphate and potash gave well marked responses. The bonemeal treatment had a depressing effect.

Mixed Farming and Cultivator's Holdings.

Two cultivators' holdings of $7\frac{1}{2}$ acres and 8 acres under 66.6 per cent. and 50 per cent. intensities of green manuring respectively and one mixed farming block on 8 acres without green manuring were cropped according to the scheme. Highest yields of both *kharif* and *rabi* crops were recorded from the holdings under 66.6 per cent. intensity of green manuring. The block under 50 per cent. intensity of green manuring

was the next best. The yields recorded from the mixed farming unit were the lowest of the three holdings. Cost accounts are being maintained to compare the economics of the three systems.

(b) AGRICULTURAL SUBSTATION, KARNAL.

Season and Crops.

The *kharif* season crops could be sown in good soil moisture, for 7.44 inches of rainfall had been received in the preceding month of June. They put on good growth as about 9.4 inches of precipitation had been received during July and August. Grain formation suffered owing to dry September and October when irrigation could not supplement rainfall.

Poor soil moisture conditions in November made it imperative in most cases application of *palewa* irrigatron for obtaining good germination and stand of the cereal and fodder crops. This somewhat delayed sowing which coupled with dry hot weather during March and April caused shrivelling of grain, reduced yields of *rabi* crops.

General.

Area : The details of farm area classification are as under :—

(i) Sugarcane Substation	51 acres.
(ii) Direct Cultivation	1,267 acres.
(iii) Pasture for Tharparkar herd	139 acres.
(iv) Rent for cultivation	202 acres.
(v) Under <i>batai</i> cultivation	104 acres.
(vi) Leased for grazing	144 acres.
(vii) <i>Usar</i> land	35 acres.
(viii) Under roads and buildings	212 acres.
	TOTAL 2,154 acres.

Cropping Plan.

The plan of cropping was more or less on the same lines as in the previous years. The experimental area, however, greatly increased in the year under report.

Irrigation.

The canal water supplies having a discharge of 7.3 cusecs only and working on rotational basis was a limiting factor in meeting the normal requirements of 2,154 acres farm. The scarcity was felt more acutely during the *rabi* season when rainfall was deficient.

Machinery and Agricultural Operations.

Tractor T.D. 14 worked throughout the year. Tractor D. 4 was purchased during November, 1946 but could only be worked in *zaid-rabi* and *kharif* seasons. All other tractors having finished their working life for various reasons remained idle. Only one bullock mover was in working order. The two Marshall Thrashers did not work satisfactorily and most of the thrashing was managed by bullock labour. Chopper G. 3 required constant repairs and replacement of parts and chopping of fodder presented great difficulties. This entailed loss of fodder.

Incidence of Pests and Diseases.

This substation endeavours to meet to a great extent the requirements of pedigree New Pusa " seeds. During the year a set-back was caused to this actively due to

permit system in view and transport difficulties in meeting the full demands of improved seeds in time. 85.5 mds. of wheat varieties and 20 lbs. of cowpeas seed were supplied during the year under report.

Rusts, maize and cowpeas were badly damaged by grasshoppers. But generally all *cereal* crops were free from pathological diseases. Black rust heavily affected the yield of wheat varieties. Barley also suffered from an attack of rust. Oats were comparatively free from *insect* *pests*. This year gram wilt severely infected the crop in Block No. 7 M.F., which reduced the grain yield.

Nitrogenous Manuring Experiments.

(i) *Experiment with ammonium nitrate*.—Ammonium nitrate alone and in mixture with L. N. T. were compared with sulphate of ammonia on paddy and sugarcane. From equal amounts of nitrogen, ammonium nitrate and its mixture with L. 2 and 3 per cent. of T. N. T. were found as effective as the standard fertilizer sulphate of ammonia. This was the third year of the experiment and no deleterious effect was observed on the crops.

(ii) *Experiment on the effect of dipping paddy seedlings in night soil*.—This experiment was started in 1945-46 at the suggestion of the Government of India, based on the observations made by the Indian Agricultural Mission to China. The roots of the paddy seedlings were dipped in a mixture of equal parts of night soil, wood ashes and ordinary soil before planting them out. The underlying idea is to give a good start to the growing seedlings. The yields of paddy obtained from various treatments showed that the dipping of seedling in a solution of night soil, wood ashes and ordinary soil were larger than the other treatments, viz., (i) farmyard manure plus wood ash plus soil and (ii) N. PK equivalent to nutrients contained in the former treatment.

Phosphate Experiments.

(i) *Effect of different doses of superphosphate on berseem after paddy*.—This was the third year of the experiment. The yields of berseem are given for comparison.

TABLE III.

Fodder outturn in mds. per acre.

<i>Superphosphate applied at the rate of lbs. P.A.</i>					
<i>Nil</i>	40	80	120	160	200
436.6	582.5	625.3	708.2	712.3	695.1

A definite increase in fodder yield was indicated by application of phosphate to berseem crop. There was a successive increase upto 120 lbs. P205. The difference amongst 120, 160 and 200 lbs. P205 treatments was small.

(ii) *Direct and indirect manuring of paddy in different rotations*.—This experiment started in 1944-45 was continued but with a change in the treatments. The rotations made comparison were (i) paddy-wheat, (ii) paddy-fallow, (iii) paddy-berseem, (iv) paddy-peas and (v) paddy-grass. The manuring treatments in rotations (i) and (ii) along with yields of paddy and wheat in maunds per acre are given below. In rotation (i) fertilizers were applied to both the crops.

TABLE IV.

*Yields in maunds per acre.**N as ammonium sulphate: P205 as super: K2O as Pot. sulphate.*

Treatments in lbs. per acre. N. P205. K20.			Rotations.			
			(i) Paddy.	Wheat.	(ii) Paddy.	Fallow.
40 + 40 + 60			19.7	19.9	24.2	..
Nil + 40 + 60			19.0	9.9	18.3	..
40 + 40 + Nil.			24.5	16.7	24.8	..
40 + Nil. + 60			22.6	15.7	22.9	..
40 + Nil. + Nil.			22.4	18.2	25.0	..
Nil. + 40 + Nil.			17.5	10.5	20.5	..
Nil. + Nil. + 60			22.9	12.5	17.2	..
Nil. + Nil. + Nil.			17.1	12.8	17.9	..
Critical difference 5% level.			7.1	3.0	3.5	..

Application of nitrogen in general increased the yield of paddy and wheat in both the rotations.

In paddy-legumes rotations the treatments were slightly different. The dosage of phosphate and potash were doubled. The yields from the three rotations are given below:—

TABLE V.

*Yield in maunds per acre.**N as ammonium sulphate: P205 as super: K2O as Pot. sulphate.*

Treatments in lbs. per acre. N. P205 K20.						Rotations.				
						(iii) Paddy.	Berseem.	(iv) Paddy.	Peas.	(v) Paddy.
40 + 80 + 120 to legume only.						17.7	655.4	27.0	23.5	26.0
Nil. + 80 + 120 do. do.						18.1	628.0	23.7	24.0	20.3
Nil. + 80 + Nil. do. do.						18.9	625.3	20.9	22.2	21.3
40 + 80 + 120 to paddy only.						28.1	538.0	34.1	23.2	26.3
Nil. + 80 + 120 do. do.						18.4	545.4	18.4	19.8	20.4
40 + Nil. + Nil. do. do.						22.6	437.9	29.5	22.1	22.6
Nil. + 80 + Nil. do. do.						20.7	453.6	29.5	18.5	23.6
No manure to each crop . . .						18.2	436.6	22.4	22.9	19.0
Critical difference (5% level) . . .						3.8	114.8	6.1	16.4	3.6

Fooder outturn of berseem and yield of peas grain were increased by application of phosphate. On the other hand paddy yields improved by application of nitrogen. The gram crop was affected heavily by gram wilt and yields of plots was disproportionately reduced.

(iii) *Effect of Applying superphosphate to sannhemp and indigo green manured.*—

The response indicated in both the cases was small. The experiment is being repeated to confirm the results.

(iv) *Bonemeal application to paddy alone and in conjunction with farmyard manure and ammonium sulphate and aftereffect on berseem.*—This was the third year of the experiment. Bonemeal at 80 lbs. and 120 lbs. P205 per acre singly and in combination with farmyard manure and ammonium sulphate at 40 lbs. N per acre were applied to paddy. The residual effect was studied on berseem. Bonemeal application neither exhibited enhancement of yield in paddy nor in berseem. Addition of N in organic or the inorganic form, alone or in conjunction with bonemeal did not materially result in increased yields in both the crops.

(v) *Placement of fertilizer experiment.*—The experiment was started in the year under report. Guar was sown in rows 15 inches apart. Placement of fertilizer was done by drilling through a *pora* attached behind the plough and seed was sown by *kera*. In other plots, for comparison, the fertilizer was broadcast and seed was sown behind the plough. The main idea was to see if fertilizers placed about 2 inches deeper than the seed increased the yield. The results of the trial did not indicate significant differences amongst the treatments.

Green Manuring Experiment.

This is the second year of the experiment started with four green manure crops, viz., indigo, guar, sannhemp, and a mixture of the three dressed with superphosphate at the rate of 250 lbs. P205 to the green manure crops, in *khari*. At the time of sowing wheat, fertilizers 40 lbs. N. 80 lbs. P205 and 80 lbs. K2O alone and in combination with each other were applied as ammonium sulphate, superphosphate and potassium sulphate. Nitrogen alone and in combination with phosphate and potash indicated an increased yield of wheat over no fertilizer treatment. Phosphate or potash alone or in combination did not show any response. Green manure treatments indicated a small increase over control. Sannhemp proved superior to others in acre yields of wheat.

Cultivation Experiments.

(i) *Tillage-cum-manurial experiment with wheat.*—The experiment was continued with object of studying the relative merits of tillage in combination with manuring. The main tillage treatments compared were; (i) fewer cultivation with tractor plough and other tractor drawn implements, (ii) bullock cultivation with soil inversion plough (victory plough) supplemented by country plough and (iii) by country plough. The yields indicated that tractor ploughing lowered the yields and that inversion by victory plough supplemented by country plough was better than cultivation by country plough only.

Application of nitrogen whether as farmyard manure, ammonium sulphate or equal proportion of the two enhanced the yield over no manure treatment. Interaction effects between tillage and manurial treatments were not indicated by the experimental results.

A new tillage experiment was started this year with green manure crops with and without fertilizers. The object is the same as in the above experiment. However, in this experiment contrary results were obtained. Tractor ploughing gave better yields than ploughing with country plough. The general yields were low. Manurial treatments produced a small response.

Flood Water Farming Experiments.

This experiment was conducted in Block No. 6 as usual with wheat, barley, gram and *toria*. The yields are shown below:

TABLE VI.
Yields in manuds per acre.

Manurial treatments per acre.	Soil moisture treatments.	Crops under experiments.			
		Wheat.	Barley.	Gram.	<i>Toria</i> .
No manure	{ Flooded	14.2	21.8	27.8	8.0
	{ Rainfed	6.0	17.6	19.2	6.4
40 lbs. N. applied ammonius sulphate .	{ Flooded	12.8	22.6	24.0	10.5
	{ Rainfed	6.8	19.4	11.0	9.0
40 lbs. N + — lbs. P2O5 applied ammorphos.	{ Flooded	17.3	26.1	23.9	12.3
	{ Rainfed	5.8	23.7	16.3	12.3

Flooding improved the yields of wheat, barley and gram. Yields of *toria* did not indicate wide differences in acre yields. The effect of manures was not plainly manifested in the trial.

Mixed Farming Experiments.

These experiments on holdings of 8—25 and 400-acre sizes remained in progress. Their results will be examined collectively when the rotations have run their full course.

Miscellaneous Experiments.

(i) *Rotational-cum-manurial experiment for the control of gram wilt.*—The experiment was started in the year under report to study the effect of rotations in combination with different fertilizers for the control of gram wilt. The mean yield of gram crop from the trial was 2.98 mds. per acre. This was exceptionally low because of very heavy incidence of wilt. None of the treatments indicated any superiority over the other. Detailed observations on the crop will be reported by the Division of Mycology.

(ii) *Trial of virus-free seed potatoes against local seed.*—This was the first year of the experiment. Virus-free seed was obtained from Meerut and Hapur seed Depots and compared against Karnal market seed. The mean yield results are reported below:

TABLE VII.

	<i>Mds. per acre.</i>
Karnal (local)	274.4
Meerut (Disease free)	284.2
Hapur (Disease free)	279.4

The differences were small. Other observations will be found in the report of the Division of Mycology.

(iii) *Usar (Alkali) Control.*—Alkali patches were mulched to check the upward movement of salts from sub-soil to surface of the soil. Paddy berseem rotation added to the efficacy of mulching. The yields of both paddy and berseem improved on the alkaline patch under treatment.

(a) SAHIWAL HERD, NEW DELHI.

2. *Health and Condition.*—The herd was subjected to a mild attack of Foot and Mouth disease in February and Haemorrhagic Septicaemia in March. In August there was a sporadic case of 'Three-day fever'. There were also some cases of mineral unbalance in heifers and cows after freshening.

Cattle were protected against Rinderpest, Haemorrhagic Septicaemia and Black Quarter. One case of Haemorrhagic Septicaemia occurred in the inoculated young stock.

One cow yielded over 9,000 lb. and 3 over 8,000 lb. in a lactation period of 306 days. One heifer yielded over 8,000 lb., 3 over 7,000 and 3 over 6,000 lb. in 306 days.

The average lactation yield of cows which completed their lactation during the year are tabulated for different lactations:

Location.	No. of cows completed lactation.	Average lactation yield.
1st	22	5,491
2nd	22	5,600
3rd	10	6,471
4th	1	4,116
5th	5	6,810
6th	3	7,468
7th	1	5,514
8th		
9th	2	6,632

The average lactation yield of 66 cows which completed lactation during the year was 5,910 lb. in a lactation period of 296 days. The average lactation yield of 22 adult cows which completed lactation was 6,135 lb. in 296 days.

During the year under report 77 calves were reared out of 93 born. Navel ill, Pneumonia, Gastro-enteritis were responsible for 16 deaths in calves below 3 months of age. The system of calf rearing on standardised milk containing 3.5 per cent. butter fat was continued. Under this system the calves showed a rate of growth of 1.2 lb. per head, per day.

Management of Milch Cattle.

Production Capacity.	No. of cows completed lactation.	Average lactation yield.	% cows,
Below 2,000 lbs.	1	1839	1.5
2,000—3,000 „	3	2702	4.5
3,000—4,000 „	5	3449	7.6
4,000—5,000 „	7	4384	10.6
5,000—6,000 „	15	5397	22.7
6,000—7,000 „	19	6448	28.8
7,000—8,000 „	11	7340	16.7
8,000—9,000 „	4	8449	6.1
9,000—10,000 „	1	9276	1.5

The above statement shows the production capacity of cows completed lactation 75.8 per cent. cows showed a production capacity of over 5,000 lbs., 10.6 per cent. between 4,000 lbs. to 5,000 lbs. and 13.6 per cent. below 4,000 lbs. It is evident from this that a large per cent. cows can do high yields under the technique evolved in this Institute.

5. *Handling*.—Development of 'milk temperament' through handling is partially responsible for raising production capacity of over 5,000 lbs. in 75.8 per cent. cows and heifers which completed lactation with a persistency to milk for a lactation period of 10 months.

6. *Feeding stock on a ratio of 1:3.5 to 1:4*.—The calves showed daily rate of growth at one year 1.1 lb. per head. Early maturity heifers at an average service age of 1 year 7 months and 24 days of 0.95 lb. per head, and at an average first calving age of 2 years, 5 months and 4 days 0.5 lbs. per head and at the close of 1st lactation on an average age of 3 years 3 months and 26 days 1.5 lb. per head.

The average capacity of production of cows and heifers was 5,910 lbs. in a lactation period of 10 months.

7. *Four times milking*.—The rate of flow of milk secretion at 2.30 p.m. and 7.30 p.m. milkings with milking intervals of $6\frac{1}{2}$ and 5 hours was 0.81 and 0.88 lb. per hour respectively and at 3 a.m. and 8 a.m. milkings with intervals of $7\frac{1}{2}$ and 5 hours was 0.93 lb. and 0.94 lb. per hour respectively. There is not much appreciable difference in the rate of flow at the afternoon milkings nor at the morning milkings. The morning milkings show an increase flow of 0.08 lb. over the evening milkings. On the whole the intervals of milkings whether they are of short or long duration, do not show any proportionate decrease or increase in their rate of flow.

8. *Pre-milking*.—The pre-milk yield did not change in its quality when the number of milkings was reduced from 2 to one nor it had impaired the stimulation for high milk secretion. But the pre-milk yield was definitely affected to a certain extent in quantity.

The development of udder in heifers under pre-milking was well marked and their capacity of production was also definitely increased. The heifers, when "freshened," milked like well-handled cows in milk, in temperament.

9. *Early maturity Treatment.*—Twenty-two early maturity heifers completed lactation at an average age of 3 years, 3 months and 26 days with a production capacity of 5,576 lbs. per head in a lactation period of 306 days. As a result of these experiments it is now possible to assess the milk potential of bulls at the comparatively early age of five years.

The early maturity heifers attained 631 lbs. (just over $\frac{2}{3}$ adult) (body weight of 600 lbs.) at the maturing age of 1 year, 7 months and 24 days.

10. *Calf Rearing.*—Calves reared on standardised milk ration based on $\frac{1}{10}$ birth weight for a period of 8 months showed a daily rate of growth of 1.1 lb. per head.

(b) THARPARKAR HERD, KARNAL.

1. *Strength of the herd.*—The strength of the herd at the close of the year was 347 animals comprising 106 cows; 90 young male stock; 64 female stock; 14 stud bulls and 73 young calves. This registered an increase of 70 per cent. over the scheduled strength of the herd.

2. *Health and condition.*—The herd generally remained good health except for a few "yearlings" which happened because of lack of separate accommodation. Six calves died of *enteritis*, one adult died of peritonitis, four calves succumbed to colic, another four died of pneumonia and four suffered death from naval-ill. Thus mortality mostly occurred amongst the pail-fed calves. The cattle in the herd were inoculated against Hæmorrhagic septiciemia, black quarter and raider pest to portect them against these diseases.

3. *Milk yield.*—The milking herd was in good condition to yield a high overall average (wet and dry) of 14.6 lbs. per head per day. The wet average was 20.9 in spite of the fact that in the last four months of the year the No. of cows in milk decreased from 75 per cent. to about 65 per cent. Ten cows yielded over 8,000 lbs. of milk. One of the cows, Tikhteari, in her second lactation exceeded 10,000 lbs. of milk yield. This was definite improvement over the performance recorded last year. Thirteen of the heifers gave over 6,000 lbs. of milk yield during their first lactation of which two gave more than 7,000 lbs. each. Thus more than 50 per cent. of the heifers were high milk yielders.

Pre-milking.—This practice has been in vogue in the Tharparkar herd for the last several years. Conspicuous improvement in shape of the udder has been noticed. The cows have also developed mild temperament.

Progeny-testing.—Bull Tikka was subjected to progeny test over three lactations. His daughters appear to show improvement in the total milk yield over their dames. Further work is in progress.

Management of Milch cattle.—The milk yield performance of the herd is given below in the statement:—

Capacity of production.	No. of Cows.	% of Cows.
Below 200	2	3.1
2000—3000	2	3.1
3000—4000	—	—
4000—5000	6	9.2
5000—6000	20	30.8
6000—7000	22	33.8
7000—8000	5	7.7
8000—9000	8	12.3
	65	

In the herd 84.6 per cent. cows which completed lactations, show production capacity of over 5,000 to 6,000 and 9.2 per cent. fell in the range of 4,000 to 5,000 lbs. only. A very small percentage had production capacity below the range of 4,000 lbs. Thus a definite improvement has been registered by the improved technique of management evolved at this Institute.

III. STATISTICAL SECTION

Advisory.

As in previous years, the section attended to a large volume of advisory work from various divisions and helped them to analyse their data.

Investigations.

The main investigations of the section are on the dairy records of the Pusa Pedigree Sahiwal herd. A detailed report on the result of the statistical analysis of the Pusa Sahiwal Dairy data was written. A summary of the main conclusions appeared in the last annual Report. Further work on the variation in weekly averages of a few cows in different lactations was completed. The results are given in Table I. Column 1 gives the number of the week, column 2 gives the weekly mean yield of milk with the standard error and the coefficient of variation; columns 3 and 4 give the same details for the second and third lactations. An examination of the table leads to the following conclusions:—

- (i) The cows have reached their peak yield in the eighth week in the first lactation, in the sixth week in the second lactation and in the seventh week in the third lactation. By the eighth week, in general, the cows attain their maximum yield and thereafter downward trend begins.
- (ii) The milk yield increases with the lactation up to the third. For want of complete data, examination of subsequent lactations could not be made.

Work in connection with the calculations of statistical constants for the data of all the Sahiwal cows drying up in the years 1938-39 to 1945-46, was completed. Table 2 gives the weekly average milk yield after every fourth week for cows which dried during 1938-46. These averages have been obtained by weighting the simple average yields of cows by the number of cows drying up in that particular year.

An examination of the table leads to the following conclusions. All the calvers have attained their maximum milk yield some time between the fifth and ninth weeks, thereafter there appears to be almost gradual downward trend. Similar trends are noticeable in the individual years. The fifth calvers have given the best yield during the period. In the individual years, however, due to the small number of cows in some of the categories, the performances of the different calvers do not endorse such a conclusion. The coefficients of variation also fluctuate very much and do not show any definite trend. The maximum yields in the different years, are given below:—

Year.	Maximum yield.	Type of cow.	Week.
1938-39	256.33 ± 29.23	4th calvers	5th
1939-40	262.00 ± 23.48	5th calvers	5th
1940-41	261.67 ± 27.01	5th calvers	9th
1941-42	299.33 ± 77.12	6th calvers	9th
1942-43	225.25 ± 29.36	6th calvers	5-9th
1943-44	290.00 ± 22.34	7th calvers	9th
1944-45	259.13 ± 18.29	4th calvers	5th
1945-46	260.67 ± 32.92	8th calvers	9th

The standard errors in the years 1941-42 and 1945-46 are very high and as the averages are based on few cows, no conclusion can be drawn about the performance of 6th and 8th calvers in these cases.

Preliminary work in connection with the collection of Dairy data of the Tharparkar herd at Karnal was completed. In order to compare some of the main conclusions obtained from the analysis of the data of Pusa Sahiwal herd, it is proposed to carry out an analysis of the data at Karnal.

Analysis of Pusa Sahiwal records has shown that the increase in yield by four times milking and early maturity experiments is about 60 per cent. per lactation. The yield per lactation during 1904-32 has varied from $2,553 \pm 158.9$ lbs. to $4,501 \pm 472.7$ lbs. in the first seven lactations. In the period 1932-42 the variation in the yield for the first six lactations is $4,077 \pm 251.7$ to $7,763 \pm 534.4$ lbs. Analysis of records of data in other countries on Holsteins, Jersey, Ayrshire and Gurnsey cows milked four times a day produced 149 to 160 per cent. more milk than those milked twice. So it is proposed to study the data of twenty Tharparkar cows each under two times and four times milking with a view to assess the advantages of the two systems of milking and to compare the gain by four times milking with these results.

Besides this work on Dairy data, the statistical analysis of a large number of field experiments conducted at Karnal was completed. The statistical analysis of Ammonium Nitrate experiment conducted by the Chemical Section was also completed.

TABLE I.

Weekly milk yield of all cows taken together.

Weeks.	1st Lactation		2nd Lactation		3rd Lactation	
	M $\pm$ S.E.	C.V.	M $\pm$ S.E.	C.V.	M $\pm$ S.E.	C.V.
2	25.46 $\pm$ 0.61	6.74	28.91 $\pm$ 2.32	22.69	30.97 $\pm$ 0.98	7.08
3	26.73 $\pm$ 1.07	11.28	30.46 $\pm$ 2.47	22.90	33.43 $\pm$ 1.22	8.14
4	27.21 $\pm$ 1.22	12.67	30.86 $\pm$ 2.55	23.36	34.74 $\pm$ 1.26	8.13
5	26.32 $\pm$ 1.47	15.81	31.21 $\pm$ 2.75	24.88	36.77 $\pm$ 0.98	5.97
6	26.93 $\pm$ 1.18	12.43	32.43 $\pm$ 2.47	21.57	38.77 $\pm$ 0.77	4.42
7	28.34 $\pm$ 1.04	10.42	32.36 $\pm$ 2.39	20.85	39.29 $\pm$ 1.33	7.58
8	28.79 $\pm$ 1.11	10.90	31.62 $\pm$ 2.44	21.81	39.20 $\pm$ 1.30	7.41
9	28.63 $\pm$ 0.74	7.34	30.39 $\pm$ 2.71	25.26	38.69 $\pm$ 1.03	5.95
10	28.21 $\pm$ 0.70	7.03	29.61 $\pm$ 2.70	25.80	38.57 $\pm$ 0.93	5.40
11	27.41 $\pm$ 0.91	9.35	30.25 $\pm$ 2.60	24.30	38.45 $\pm$ 1.23	7.14
12	27.61 $\pm$ 0.59	6.08	29.95 $\pm$ 2.43	22.92	38.03 $\pm$ 1.29	7.61
13	27.27 $\pm$ 0.97	10.06	28.57 $\pm$ 2.24	22.17	36.74 $\pm$ 1.12	6.79
14	27.20 $\pm$ 1.09	11.30	27.16 $\pm$ 2.49	25.90	36.34 $\pm$ 1.21	7.44
15	27.14 $\pm$ 0.84	8.77	27.32 $\pm$ 2.36	24.44	36.11 $\pm$ 1.01	6.23
16	26.66 $\pm$ 0.71	7.50	26.75 $\pm$ 2.72	28.80	35.77 $\pm$ 0.99	6.16

TABLE I—*contd.**Weekly milk yield of all cows taken together—contd.*

Weeks.	1st Lactation		2nd Lactation		3rd Lactation	
	M±S.E.	C.V.	M±S.E.	C.V.	M±S.E.	C.V.
17	25.41±0.76	8.48	25.95±2.48	29.03	34.63±1.29	8.33
18	25.14±0.86	9.68	26.23±2.57	27.73	34.26±1.28	8.34
19	24.91±0.91	10.34	25.30±2.29	25.59	33.46±1.57	10.46
20	24.29±0.93	10.83	24.43±2.24	25.92	32.31±1.87	12.90
21	23.61±0.79	9.48	23.70±2.09	24.96	32.40±1.03	7.13
22	23.02±0.82	10.07	23.96±2.11	24.86	31.31±1.20	8.58
23	22.61±0.95	11.94	23.18±2.28	27.76	30.51±1.11	8.13
24	22.86±0.95	11.77	22.43±2.13	26.91	29.66±1.09	8.20
25	22.36±0.85	10.71	22.31±2.44	28.98	29.29±0.92	7.01
26	21.70±0.73	9.49	21.57±2.25	33.64	28.51±1.08	8.46
27	21.73±0.83	10.86	20.22±2.12	29.60	27.51±1.16	9.44
28	20.80±0.92	12.52	20.73±2.09	28.52	26.60±0.79	6.61
29	20.78±0.53	7.22	19.95±2.14	30.37	25.91±0.81	7.01
30	20.04±0.67	9.46	19.21±1.75	25.78	24.86±0.68	6.14
31	20.11±0.80	11.27	18.55±1.56	23.77	24.49±0.51	4.65
32	19.68±0.82	11.74	17.84±1.45	23.06	24.40±0.44	4.00
33	19.39±0.94	13.70	17.96±1.38	21.76	23.06±0.70	6.78
34	19.16±0.78	11.45	17.25±1.29	21.09	22.08±0.53	5.35
35	18.43±0.87	13.37	16.61±1.11	18.94	20.91±1.01	10.77
36	18.07±0.87	13.63	16.29±1.18	20.45	19.69±1.19	13.48
37	17.50±0.82	13.30	14.78±1.16	22.20	18.48±1.50	18.12
38	16.63±0.95	16.09	14.96±1.11	20.93	17.28±1.76	22.80
39	18.09±1.08	19.03	14.96±1.15	21.74	15.28±1.91	27.98
40	16.16±1.15	20.11	14.14±1.37	27.31	16.40±2.25	30.73
41	15.82±1.21	21.57	13.63±1.54	31.93	15.34±2.55	37.13
42	15.41±1.32	24.30	13.68±1.47	30.38	14.66±2.62	39.93
43	15.62±1.31	23.68	13.36±1.53	32.29	13.26±2.73	46.07

TABLE II.

Weekly Average Milk Yield, after every fourth week, for cows which dried during 1938-46.

	Heifers	2nd Calvers	3rd Calvers	4th Calvers	5th Calvers	6th Calvers	7th Calvers	8th Calvers.
5	N M±SE CV 178 167.35±3.19 25.47	125 200.32±4.95 27.62	74 223.82±2.74 10.55	50 246.80±5.64 16.15	34 249.59±8.28 19.34	16 241.38±13.35 22.12	4 256.50±20.66 16.11	5 230.00±24.75 24.06
9	N M±SE CV 179 163.37±3.21 26.29	123 191.65±5.48 31.72	74 211.35±6.67 27.15	51 234.69±5.82 17.71	34 242.85±9.64 23.15	16 239.25±16.74 27.99	4 240.75±22.36 18.57	5 235.80±27.48 26.06
13	N M±SE CV 177 162.45±3.03 26.43	121 173.98±5.15 32.54	75 191.73±7.04 31.81	51 213.10±5.84 19.58	34 221.59±9.75 25.65	16 213.25±15.99 30.00	4 218.50±19.59 17.93	5 211.60±30.93 32.68
17	N M±SE CV 176 141.80±3.01 28.13	122 151.33±5.02 36.64	74 169.98±6.72 54.02	51 189.61±5.76 21.68	33 202.21±9.85 27.97	16 192.56±12.13 25.21	4 190.50±24.82 26.06	5 196.40±30.50 34.72
21	N M±SE CV 175 132.31±2.92 29.16	127 125.36±5.44 48.94	72 151.71±7.07 39.55	51 169.88±6.41 26.95	32 176.44±14.33 45.94	15 170.53±11.61 26.36	4 183.75±24.26 26.41	5 183.60±34.78 42.60
25	N M±SE CV 174 120.12±2.89 31.69	115 119.12±4.37 39.35	69 137.33±6.75 40.82	50 148.04±6.57 18.97	34 159.21±10.15 37.18	16 153.56±11.38 29.64	4 161.00±18.85 23.41	5 169.60±36.30 47.85
29	N M±SE CV 170 112.12±2.77 32.21	113 104.13±4.37 44.60	66 123.62±5.92 38.91	50 127.00±6.58 18.99	31 124.00±12.60 50.12	16 133.06±13.05 39.23	4 143.25±20.34 28.40	4 169.30±41.81 49.33
33	N M±SE CV 169 100.28±2.81 36.45	107 89.20±3.89 54.92	64 104.63±6.02 46.03	48 107.19±6.73 43.49	30 119.17±11.21 51.51	16 113.75±13.31 46.80	4 124.75±23.30 37.36	4 160.00±42.15 52.69
37	N M±SE CV 162 90.03±2.78 39.24	97 77.04±3.68 47.11	59 91.10±5.41 45.68	44 92.05±6.49 46.75	27 96.33±11.44 61.31	14 96.57±11.49 44.52	4 109.50±26.62 48.63	2 209.00±11.00 7.44
41	N M±SE CV 153 81.47±2.79 33.80	78 71.14±3.42 47.80	55 72.69±5.28 72.80	39 73.03±5.99 81.10	28 76.39±8.97 69.10	13 83.23±11.34 49.14	2 150.00±35.00 33.90	2 190.50±7.50 3.57

IV. PROGRAMME OF WORK (1947-48)

Agronomy.

1. Manurial experiments to determine the relative values of nitrogen in different manures and sulphate of ammonia and the estimation of the recovery of nitrogen by the crops and the changes brought about in the soil (In collaboration with the Chemistry Division).
2. Further development of the results of the previous experiments on the phosphate manuring of legumes and their direct and indirect effects on succeeding food and fodder crops.
3. Paddy manurial trials at Karnal with nitrogenous manures and bonemeal.
4. Experiments on the placement of fertilizers.
5. Soil fertility building experiments with green manures and heavy doses of organic and inorganic manures.
6. Ley farming—manurial trials with grasses and legumes for pasturage.
7. Acclimatisation and manurial trials with improved clovers.
8. Collection of fodder grasses and legumes.
9. *Flood water farming*.—Utilization of surplus river water during the monsoon for growing *rabi* cereals, gram and oilseeds.
10. *Mixed farming experiments*.—Continuation of old series.
11. New 6-acre holdings for testing improved rotations with phosphate manuring.
12. Tillage experiments for the cultivation of wheat and paddy.
13. *Crop-weather-observations*.—The correlation of certain agronomic characters of wheat and sorghum with weather factors.

Breeding Herd.

1. Handling of the Sahiwal and Tharparkar stock for the development of "milk temperament".
2. Feeding of stock on balanced rations for growth, early maturity, high milk production under four times milking.
3. Four times milking as a means of stimulation of high milk yield in Indian milch cattle.
4. Pre-milking as a means of stimulation for milk secretion, to train heifers to milk before calving and to prevent udder trouble.
5. Early maturity treatment to prove milk capacity of heifers before 4 years of age and to test bulls for transmitting capacity of high milk yield before the age of five years.
6. Calf rearing on standardised milk (3.5 per cent. butter fat) based on a scale of 6th of birth weight for an even rate of growth and as a measure of control against underfeeding in calves.

REPORT OF THE DIVISION OF BOTANY

I. INTRODUCTION

During the year under review, progress was maintained in respect of the programme for research and post-graduate training, under the handicap imposed by shortage of staff. Dr. S. Ramanujam who had been in charge of the cytogenetical investigations for the past eight years was selected as Director of the Central Potato Research Institute which is in process of formation. Our congratulations go to him but his departure has left a gap which will be difficult to fill. Mr. G. S. Murty and Mr. P. S. Parsai left during the course of the year to undertake courses of advanced study in the United States of America and Australia, respectively.

The Division of Botany continued to be responsible for the running of the following schemes financed by the Indian Council of Agricultural Research:—

Potato Breeding Scheme (located at Simla and Bhowali).

Wheat Breeding Scheme for the Hills (located at Simla).

Tobacco Research Scheme (located at Guntur).

The last-mentioned scheme was however taken over by the Indian Central Tobacco Committee with effect from the 1st April 1947.

Two new schemes, also financed by the Indian Council of Agricultural Research, namely the scheme for the establishment of a Nucleus Organization for Plant Introduction, and the scheme for the improvement of the Maize Crop, came into operation. Only part of the sanctioned staff could be recruited during the year and work could not be taken up on a full-scale.

In addition to the above, work on a small scheme for testing the germination and quality of vegetable seeds was undertaken at the request of the Agricultural Development Commissioner with the Government of India.

The results obtained under these schemes are briefly referred to in the present report. Fuller reports are being submitted to the Indian Council of Agricultural Research. The results obtained at the permanent sub-station at Pusa are also briefly referred to.

There was a substantial increase in the number of post-graduate students admitted and considerable attention was paid to their training. One Research Fellow and honorary researchers were admitted during the year.

II. RESEARCH

Applied Genetics

1. *Study and improvement of Indian Wheat (Triticum spp.).*

(i) *Survey of Indian Wheat.*—The study of the all-India collection of wheats comprising of nearly 1,200 samples was continued and observations on morphological and economic characters were recorded. One study was impeded by an unusually severe epidemic of black rust.

(ii) *Description and registration of commercially important varieties and those of special interest for plant breeding.*—The varieties of wheat under study for registration were grown and described as in the previous years. The report on the registration of 24 N.P.* wheats has been written up and is being sent for publication.

* The wheats evolved at the Indian Agricultural Research Institute have now been given the prefix N.P.=(New Pusa).

(iii) *Study of wild and cultivated species and allied plants.*—The F₁ generation of the intergeneric hybrids, *Triticum vulgare* × *Sorghum cereale* and *T. vulgare* × *Aegilops*, was under study. The promising selections were continually infected with all rusts and although some of them were observed to be highly resistant to yellow the *S* rusts and although some of them were observed to be highly resistant to black rust. A few suitable and lower rust, some of them were found to be resistant to black rust. A few suitable selections were, however, made on the basis of other economically valuable characters. The F₂ population of the crosses *T. vulgare* × *T. durum* and *T. vulgare* × *T. spelta* was under observation and was found to be susceptible to rusts. The progenies of the different intergeneric crosses involving *T. vulgare* × *T. durum*, *T. durum* and *T. turgidum* were studied for important agronomic characters and further suitable selections were made. The strains of *Panicum* wheat type amphiploid were grown and studied under field conditions and were found to be late in maturity and also susceptible to black rust.

(iv) *Experiments on rust resistance.*—The work of testing of varieties including new strains of hybrid origin for resistance to rust was continued in cooperation with the Division of Mycology. The results of the tests are summarised in the report of that Division.

(v) *Screening for rust resistance.*—All selections from progenies of crosses were artificially inoculated and tested for rust resistance. Although there was a severe incidence of rust, especially black rust, in all cases under report, many cultures were found to be almost free from the attack of all the *S* rusts. Suitable selections were made for further observations.

(vi) *Preliminary field tests with promising hybrids.*—The N.P. hybrids, which have been recently evolved at this Division, were under field tests at 15 places in India. The results of the trials at 8 places, which were at hand at the time of writing, indicated that as compared to the local varieties the highest yield was obtained from the new hybrids at all the places. Some of them showed a considerable degree of resistance to rusts. Mention may be made of hybrids N.P. 110, N.P. 111 and N.P. 112 which are specially promising. The last named is the best among all the N.P. wheats.

(vii) *Study of the influence of environment on quantitative and qualitative characters.*—From among the 100 varieties grown in the previous years at Delhi, Pusa and Ludhiana with a view to testing their performance under different climatic conditions, 19 varieties, which were observed to show marked reaction to change in environment, were grown at the above 5 places and at Srinagar and observations on their quantitative and qualitative characters recorded. (a) In an experiment to find out the effect of sowings at different intervals on yield and other plant characters, 11 varieties were under study. Although the yield was found to decrease with later sowings in all the cases, the varieties reacted to different degrees under different sowings, the indicating which of them could be preferred for cultivation under different sowing dates.

(viii) *Wheat-maize-soyabean trials.*—In order to determine the response of different wheat varieties to the different levels of manuring an experiment was conducted in a "Randomised Block" layout in which six varietal treatments (five varieties N.P. 101, 103, 110, 111, 112, and the sixth treatment being the mixture of the five varieties) were tested against three levels of fertility and the control, which did not include any fertilizer. The three levels of fertility were (a) Nitrogen 20 lb., 10 lb. organic and inorganic each, Phosphorus acid 40 lb. and potash 20 lb.; (b) half the above quantities and (c) Nitrogen 10 lb., manure 10 lb. per acre.

The observations on vigour, plant height and tiller number showed that in general the higher the level of fertilizers the greater the increase in these characters.

However no definite conclusions could be arrived at with regard to the effect of these levels of fertilizers on the grain yield as due to rust both yellow and black and to the lodging which was partly due to rust and partly to excessive vegetative growth.

in some treatments, the experiment was initiated. Thus out of 18 plots under each treatment there was laid up (a) 2 plots under treatment (a), in 3 plots under treatment (b), in 5 plots under treatment (c) and in two plots each under control.

(ix) *Study of leaf hairs and its classification*.—Preliminary observations on number, arrangement and structure of hairs on different parts of the leaf in 100 varieties of species of *Triticum* showed that the study of the leaf hairs is undertaken in addition to the study of other characters, would be very useful in the identification of varieties.

(x) *Study of the role of natural selection in parental selection and hybrid generation*.—With a view to finding out how a highly heterozygous inbreeding population responds to natural selection year after year a varietal mixture and a segregating hybrid population have been under study with particular reference to qualitative and certain quantitative characters. Plants with certain combinations of characters have been found to become predominant in the population under the stress of natural selection.

2. Breeding for disease resistance and other qualities.

POTATO (*Solanum tuberosum* and *solanum* spp.)

(1) Performance tests of hybrid cultures:

(a) *Yield trial of promising hybrids*.—A number of hybrids bred at the Simla sub-station is tested in this Division with a view to evolving hybrids suitable for the conditions of the plains of India. Hybrids which do well successively for at least 3-4 years are put under larger scale trials. 37 promising hybrids which did well in a preliminary yield trial in 1945-46 were again tested against the 3 local varieties during the year under report. Observations on growth, tipout, incidence and diseases, susceptibility to frost, yield and tuber characters were recorded. Hybrids S.H. 10, 45, 209 and 2,090 appear to be very promising.

(b) *Performance of hybrids under progeny rows*.—1,278 hybrids were under observation and 613 hybrids were selected for further study. 45 hybrids which did well in the previous years were multiplied for detail observations and 15 hybrids were selected for including them in a preliminary yield trial next season.

(ii) *Experiments with "tops"*.—Preliminary observations had indicated that crop raised from "tops" of *Phalva* compared not unsatisfactorily with that raised from whole tubers. It was then suggested that it may be possible to improve the yields from "tops" under suitable spacing and manuring. Accordingly an experiment initiated in 1944-45 with 3 spacings ($1\frac{1}{2} \times 6'$, $1' \times 6'$ and $9' \times 6'$) and 3 manurial treatments (no manure, a manurial mixture before planting and the same after planting) was conducted for 3 years. The results indicated that "tops" of *Phalva* yielded slightly less than whole tubers under all treatments. Experiments with sprouts are being continued at the Simla Sub-station.

(iii) *Experiments on the artificial production of chimeras*.—Grafts involving potato, tomato, datura, *Nicotiana glauca* and other solanaceous plants were made and the chimeral shoots obtained in certain cases were under study. Terephthal shoots of *N. glauca* were obtained as a result of grafting the skin of tomato on the former and subsequent decapitation. A few apparently chimerical shoots of *Datura* grafted on *N. glauca* were found to be completely sterile.

TOBACCO (*Nicotiana* spp.)

Breeding strains of N. rustica with high nicotine content.—The F₂ progenies of the intervarietal crosses were grown and a number of single plants selected on the basis of growth, leaf size, leaf colour, leaf puckering and maturity. A preliminary yield trial with 5 promising hybrids was conducted along with N.P. 15, the standard

variety, in 5 replications, each of 10 rows of 10 plants each. Besides the characters mentioned above, observations were also taken on number of leaves and yield. Two hybrids appeared to be superior to N.P. 18 in many respects.

PIGEON PEA [*Cajanus Cajan* (L.) Mill sp.]

Wilt resistance tests with 61 cultures including 6 N.P. types were continued in an artificially infected field in collaboration with the Division of Mycology. The percentage of deaths due to wilt ranged from 0.00 to 96.4 per cent.

Selection for early maturity, wilt resistance and bold seededness was continued in the F_3 progenies of the cross between N.P. 69 and Cawnpore 132.

LINSEED (*Linum usitatissimum* L.)

The selections of strains resistant to linseed rust were grown along with N.P. types and hybrid cultures both at Delhi and Karnal. The incidence of rust was heavy at both the places. At Delhi out of 168 cultures tried for resistance only 4 were found to be infected with rust and at Karnal only 3 showed infection out of 105 strains. At both these places the susceptible parents of these cultures, hybrids under distribution and N.P. types were affected to varying degrees.

Selections combining rust resistance, early maturity and other economically-useful characters were made in the F_2 progenies of crosses between rust immune strains bred in this Division and very early maturing provincial linseed types.

CHILLI (*Capsicum annum* L.)

Progenies of the cross between an Indian type and a Hungarian variety were under observation and suitable selections based on high yield and fruit colour, size and shape were made.

3. Study of hybrid vigour and the possibility of its exploitation in agriculture.

(i) *Maize*.—Experiments on inbreeding and hybrid vigour were continued under the scheme for the improvement of maize in India, financed by the Indian Council of Agricultural Research. A number of commercial varieties, inbreds, single and double crosses imported from foreign countries were under study. A few single and double crosses obtained from Australia were found to be promising. Suitable material was selected for work on the improvement of methods of hybrid seed production and experiments on selfing and sib-mating, synthesis of high yielding strains, conservation of hybrid vigour and convergent improvement were undertaken.

(ii) *Causes of hybrid vigour*.—With a view to finding out the scientific basis of heterosis in plants, a detailed study has been undertaken and suitable crosses were made in Sesamum, brinjal and tobacco for the purpose.

4. Other genetical investigations.

(i) *Leaf mutations in gram* (*Cicer arietinum*).—It has now been confirmed that the normal leaf type results from the interaction of three complementary genes and that each of these genes in the homozygous recessive condition produces the particular mutant. The results have also confirmed that the gene, *nlr*, is responsible for the expression of the manifold characters of the "narrow-leaf" mutant. The triple recessive *slr^{slr} lv^{lv} nlr^{nlr}*, observed in the F_2 population of the cross, "tiny-leaf" × "simple narrow", differed from the "tiny-simple" in having still narrower leaves with deeper lobing which may have been caused by the gene, *nlv*.

(ii) *Inheritance of sex in Luffa*.—Previous results on the inheritance of the sex forms in the genus *Luffa* were confirmed.

(iii) "Male-sterile" mutant in tomato.—A male-sterile mutant having thick leaves without interfoliar leaflets was isolated in one of the tomato cultures; crosses were attempted with a view to studying the inheritance of the characters.

(iv) "Cawnpore Mutant" in Pigeon pea (*Cajanus Cajan*).—The F_2 and F_3 progenies of crosses involving the "Cawnpore Mutant" (*Cajanus obcordifolia*) and the normal were studied. The results obtained support the conclusion arrived at earlier that there are duplicate genes governing the inheritance of the leaf and the keel in pigeon-pea.

From the study of the F_1 and F_2 progenies of crosses involving the "bunchy" mutant and the "Cawnpore" mutant, it was observed that, while the normal habit and the normal type of keel was dominant over the mutant characters, these characters segregated independently of each other on the normal dihybrid basis.

(v) "Sepaloid" mutant in Pigeon Pea (*Cajanus Cajan*).—The inheritance of the mutant character, observed in C.P. type 3, was found to be governed by a single pair of recessive genes. It was interesting to note that the "sepaloid" character was mostly associated with the "simple" nature of leaves; leaves in pigeon pea being normally trifoliate. One plant, however, was found to have normal leaves and showed the sepaloid character, thereby indicating that the genes conditioning "sepaloidy" and "simple leaf" are different but closely linked; no plant was found showing simple leaves and the normal type of flower. The investigations will be continued.

(vi) *Linum grandiflorum* $\times$ *L. usitatissimum*.—Attempts were made to cross the former species, an ornamental garden plant known also for its resistance to linseed rust (*Melampsora lini*), with linseed. These gave normal types of capsules which, however, yielded only a few all-developed seeds.

Attempts will be made to culture these seeds on artificial media.

(vii) "Extra-glume," brached-ear and glume colour in wheat.—Inheritance of these characters in the progeny of the crosses *T. vulgare* $\times$ *T. Varilovi* and *T. Varilovi* $\times$ *T. sphaerococcum* was under study.

CYTOGENETICS

1. The Oleiferous Brassicae

(i) *Classification*.—The all-India collection of the cultivated *Brassicae* was grown and morphological characters verified and the system of cytotaxonomical classification into varieties and species evolved in the Division was confirmed.

(ii) *Inbreeding*.—Inbreeding in a number of diploid types of toria (*B. campestris* var. *toria*) and Sarson (*B. campestris* var. *sarson*) was continued and notes on the morphological characters of the inbred progenies were taken.

(iii) *Genetical studies*.— F_1 progenies of crosses between tetraploid toria (♀) and the "dyad" mutant (♂) showed the normal character. Further crosses were made to study the inheritance of this character. Crosses between diploid toria (♀) and the "dyad" mutant (♂) gave only matromorphic plants, presumably of apomictic origin, in the F_1 generation. This will be verified in the coming season.

Crosses made between the normal and the "clumped pollen" mutant in toria gave F_1 plants showing the mutant character; the inheritance of this character will also be studied further.

Studies on the inheritance of male-sterility in toria and female-sterility in taramira (*Eruca sativa*) indicated that both, these characters were recessive governed by a two-factor difference.

The study of inheritance of self-sterility in taramira was continued; the data are being analysed.

(iv) *Artificial induction and study of polyploids.*—Large progenies from single-plant selections of colchicine-induced autotetraploids of the several species of *Brassica* under study were grown and studied with special reference to morphological characters and fertility: plants with high fertility and having such other useful characters as profuse branching, close-strung siliques, etc., were selected for further study. In *toria* some cultures were found to be as highly seed-fertile as the diploids.

The study of the causes of sterility in autotetraploid *B. campestris* with special reference to cytological features was continued. Cultures comprising selfed and open-pollinated parental progenies and intra-variatal and inter-variatal crosses between them were grown and studied from the points of view of vigour of plants, cytological features and seed-fertility. The data are being analysed.

Preliminary experiments on the comparative growth and development in diploid and autotetraploid yellow sarson (*B. campestris* var. *sarson*) were undertaken. The results, which will be confirmed by further work, indicated the following:—

(a) Diploid plants were taller than the tetraploid in the early stages of growth; later, however, the latter significantly outgrew the former in height. (b) The stems of the tetraploids were thicker and the leaves longer and broader. (c) In the diploids, branching was initiated earlier and there were more branches per plant. (d) Although the roots of the tetraploids were thicker, the tetraploid root system, in general, was no less developed than that of the diploid in respect of the number and length of roots and rootlets and their total fresh and dry weights. (e) Similarly, there was no significant difference between the total fresh and dry matter produced by the diploid and the tetraploid forms. (f) The tetraploids flowered about a week later, but continued over a longer period; they however, produced less flowers per plant than the diploids; the size of the pollen grains was bigger and pollen sterility slightly higher in the tetraploids. (g) There were significantly more ovules per ovary and more seeds per silique in the diploids; the two forms, however, did not differ significantly as regards the total number of silique per plant. The total seed yield (by weight) per plant, was significantly greater in the diploids. The seeds of the tetraploids were significantly bigger and heavier. (h) The tetraploid population contained a higher number of natural crosses with diploid *rai* (*B. juncea*) than the diploid progenies; both the forms, however, showed similar extent of natural cross pollination with *toria*.

2. Fundamental Cytogenetical Research

(i) *Colchicine-induced polyploids of crop plants.*—The C_2 progenies of autotetraploids of the type N.P. 51 and the C_2 progenies of autotetraploids of four other types of chilli (*Capsicum annuum*) were grown along with their corresponding diploids and studied with reference to fruit formation and seed-setting. In the case of the former autopolyploids, no appreciable improvement in fruiting and seed-setting was apparent in spite of about eight years of selection done at Delhi, Pusa, Simla and Guntur. Crosses were attempted between representative plants among these and those from the autotetraploids obtained in the other N.P. types with a view to studying the effect of hybridity on fertility. A number of "male-sterile" plants, natural triploids, a partially asynaptic diploid plant and "interchanged heterozygotes" were isolated among these populations and studied cytologically.

Preliminary notes on the comparative growth and development in diploid (N.P. 25) and autotetraploid gram (*Cicer arictinum*) were recorded; the data are being analysed.

Preliminary studies on the comparative growth and development in diploid and autotetraploid forms of *Sesamum orientale* (N.P. 6) were undertaken and the following tentative results obtained: (a) The seeds of the two forms started germination almost simultaneously; germination in the tetraploids was rather more ununiform and the germination period more protracted. (b) The tetraploid seedlings showed slower growth

and delayed initiation of branching; at maturity, however, both the forms were almost equally tall and vigorous. (c) Considering the plant as a whole, the tetraploids produced significantly on the greater number of branches per plant. (d) The tetraploids started flowering about five days later, flowered over a longer period and produced more flowers per plant; the total number of capsules produced per plant and also per branch were, however, much lower in the tetraploids. (e) The tetraploids had fewer ovules per ovary and very few good seeds per pod than the diploids. Dissection and study of developing embryos in the two forms indicated that a larger number of developing seeds in the series of the tetraploids contained embryos than were finally realised as good seeds. This was due to the very uneven rate of development of the embryos within the same ovary and to the eventual collapse of many among them before maturity; in the diploids, nearly all the ovules contained uniformly growing embryos which ultimately matured into good, viable seeds. The seeds of the tetraploid were significantly bigger and heavier. (f) A number of diploid plants of *S. orientale* were observed in the tetraploid progenies; these arose presumably through apomixis. Natural crosses with *S. indicatum* were also observed among the tetraploid population. The diploid populations were uniformly diploid and showed no natural crosses.

Crosses were attempted between tetraploid forms of the different N.P. type to study the effect of hybridity mainly on fertility.

Reciprocal crosses between the diploid and tetraploid forms (N.P. 6) resulted in anamorphic plants in each case presumably arising through apomixis; no triploids were obtained.

The A_5 generation of the amphidiploid, *S. orientale* ($2n=26$) and *S. prostratum* ($2n=32$), was grown and studied with regard to cytological features, fertility and breeding behaviour. As in previous years, pollen meiosis was found to be quite regular in them; the plants however, showed varying degrees of pollen-sterility and varying numbers of unviable "developed" ovules, besides viable seeds. The amphidiploid bred fairly uniformly for the different characters. However, one white-flowered amphidiploid, one natural cross of the amphidiploid with diploid *S. orientale* and six F_1 hybrids, arising through haploid parthenogenesis in the amphidiploid, were discovered in these progenies. One of the parthenogenetic hybrids was observed to be fairly pollen fertile following dyad formation during pollen meiosis; the other parthenogenetic hybrids were totally sterile.

(ii) *Collection and study of wild relatives of crop plants.*—The collection of wild and allied species and genera of crop plants was maintained for study; a number of additions to the collection were made. Suitable forms among these were used for hybridisation. The following are of particular interest:—

Sesamum orientale ($2n=26$) $\times$ *S. prostratum* ($2n=32$).—Further work was done on the utilisation of the wild Indian species, *S. prostratum*, for breeding economic strains of *til*, *S. orientale*, resistant to phyllody and to the caterpillar pest, *Antigastra catalamalis*. The cytology of the triploid hybrid, $2n=42$, obtained by back crossing the amphidiploid *S. indicatum* ($2n=58$) to *S. orientale*, was studied in detail. It showed a Drosera type of chromosome pairing at diakinesis and metaphase I; 13^2+16^1 were observed. Anaphase I and the subsequent division was rather irregular resulting largely in the elimination of the univalents; Open-pollinated and selfed-progenies of the triploid hybrid as well as progenies of its back crosses with *S. orientale* showed, as in the previous year, interesting evidence indicating the transference of some characters from the wild to the cultivated species. The second generation of these progenies, which resembled *S. orientale* in respect of plant habit and fertility, was grown and studied in respect of morphological characters,

chromosome numbers and freedom from phyllody under field conditions. The promising plants were selected for further study. The plants derived from parents, in the previous year, containing $2n=27$ and 28 chromosomes were all found to contain $2n=26$ chromosomes, indicating thereby that the extra chromosomes had got eliminated. Representative plants in the progenies were crossed again to *S. prostratum* with a view to transferring more genes from the latter to the former. Reciprocal crosses were also made between the triploid hybrid, *S. indicatum* $\times$ *S. orientale*, and the diploid *S. orientale* and *S. prostratum*.

(b) *Sesamum laciniatum* Klein.—The chromosome number of this wild Indian species was determined to be $2n=32$ from a study of pollen meiosis. It may be mentioned that Raghavan and Krishnamurthy (1945) reported $2n=28$ as being the chromosome number of this species.

(c) *Sesamum radiatum* ($2n=64$) $\times$ *S. orientale* ($2n=26$).—Crosses between the species resulted in the formation of good capsules which, however, contained shrivelled seeds. The embryogeny of this cross was studied in some detail. The results indicated that, while fertilisation was effected normally, the endosperm showed abnormal development; the zygote did not appear to grow beyond the proembryo stage when it died presumably as a result of faulty nutrition owing to the abnormally developed endosperm.

When crossed to tetraploid *S. orientale*, however, *S. radiatum* gave, among shrivelled seeds, a few viable seeds which gave rise to matromorphic plants presumably of apomictic origin.

(d) *Solanum Melongena* $\times$ *S. incanum*.—Further progress was made in the isolation of plants with bitter-free fruits, comparatively greater resistance to borer attack and capacity to set fruits in the off-season.

(e) *Solanum xanthocarpum* $\times$ *S. melongena*.—In the F_2 generation, while all plants each of the *xanthocarpum* and *melongena* types appeared, the majority of plants were intermediate in respect of the parental characters like the F_1 hybrids. It was interesting to find a few plants resembling the *xanthocarpum* parent in habit of growth and having purple flowers but white fruits of the size of *S. xanthocarpum*. None of the parents had white fruits.

(f) *Lycopersicon esculentum* $\times$ *L. pimpinellifolium*.—Selections from the filial and the back-cross progenies were further studied with special reference to earliness, yield of early-ripening fruits and vitamin C content and promising results were obtained. The early-ripening selections gave fruit yields of about five to eight ounces per plant during October, while the commercial varieties yielded practically nothing during this period. The vitamin C contents of the parents and some of the selections were estimated with the co-operation of the Division of Chemistry. Vitamin C content was observed to be negatively correlated with fruit size. The varieties of *esculentum* contained from 16.1 to 29.7, *L. pimpinellifolium* 54.2 and the selections depending on fruit size, contained from 15.0 to 41.9 mgm. per 100 gm. of vitamin C.

(g) *Hibiscus esculentus* (Lady's finger) $\times$ *H. tetraphyllus*.—The F_1 generation plants were studied with regard to morphological characters, fertility, fruiting period and incidence of fruit-borer attack. The F_1 hybrids showed marked heterosis, were highly fertile and continued to form fruits throughout the winter. It is hoped to isolate from further progenies of this cross strains of the cultivated *bhindi* suitable for growing in different seasons.

PLANT PHYSIOLOGY

1. Drought resistance studies with wheat

(i) In a comparative trial of a collection of exotic and Indian varieties of wheat grown under dry and irrigated conditions, correlations between yield, 1,000-grain-weight and mean maximum temperature of the ripening period were again confirmed. On account of the early rise in temperature in February and the heavy incidence of frost, even medium-early varieties which in a normal year yielded fairly well, produced low grain yields as well as low grain weight this year.

(ii) In tests of resistance to wilting at the tillering stage, shooting stage and at flowering as well as shooting stage, it was observed that there were hardly any measurable differences in the drought resistance of all the varieties and species at the tillering stage; in wilting at the shooting stage grain yield as well as 1,000-grain-weight was considerably reduced in the late varieties, while the early varieties were not affected to the same extent; wilting at tillering as well as shooting stage had practically the same effect as that at shooting stage alone.

(iii) In tests of resistance to wilting after synchronization of developmental stages of different varieties the differential varietal reaction to wilting at the shooting stage, which was correlated with the length of the vegetative period, was not observed; in other words, all varieties behaved similarly under these conditions. The conclusion drawn last year that the temperature of the desiccation period had a considerable effect on the recovery of plants was thus confirmed.

(iv) A large-scale field trial of pre-treated seed of I.P. 4 wheat did not give any increased yield. The seeds were pre-treated with a strong solution of salt, whereas previously seeds were soaked only in water, and thus their germination suffered by nearly 30 per cent. In spite of this handicap in the early stand the yields were as good as those of the controls.

2. Photoperiodism and vernalization

An experiment involving the same nine varieties used last year, three light treatments, viz., short, normal and long day, and vernalization was conducted in pots. There was found to be a quantitative relation between the amount of light received and acceleration in the rate of development. Stem growth, tiller production and the rate of developmental process were found to be correlated. Cold and light requirements of varieties were found to be different and inter-related.

3. Studies of salt resistance in wheat

The experiment was combined with that on drought resistance. Sodium chloride at the rate of 100 gm. to 120 lb. of soil, was added to one lot of pots before sowing the seed and to the other lot after the seedlings were established. Both pre-treated (with sodium chloride) and untreated seeds were tried. In the soil made saline before sowing germination was considerably reduced and growth and yield suffered, whereas in the soil made saline later, there was little effect on growth and yield. Plants grown in saline soil recovered much more quickly than those in ordinary soil. Pre-treated seed showed better germination in saline soil.

4. Genetics of physiological characters

F_1 plants of 9 wheat crosses were grown under normal as well as long day. If there was a wide difference between the parents in their light requirement, the F_1 showed intermediate value. By exposing to long or short day the F_1 could be made to resemble either parent in regard to its light requirement.

5. Plant hormones and chemical regulation of growth and development in plants

(i) Small-scale field experiment was laid down to see the effect on growth and yield of seeds pre-treated with a solution of phyomone (a growth substance prepared by the I.C.I. and containing naphthyl acetic acid). Seeds of two varieties of maize, Pusa yellow and Simla White, were soaked in 100 p.p.m. phyomone solution for 24 hours prior to sowing. These seeds were tested against two checks, *viz.*, dry seeds and seeds soaked in water. The treatments were randomized with four replications.

The treated seeds germinated earlier and the seedlings of these had an earlier start. The controls, however, made up later. The yields were not much different in the three cases.

(ii) *Effect of the weedicide, Agroxone.*—Agroxone (I.C.I. product) is a selective weed-killer which kills off the broad-leaved plants, leaving the cereal crop undamaged. A small quantity was available (supplied *gratis* by the I.C.I.) and it was supplied at the rate of 3 cwt. to the acre to the soil before sowing wheat. Germination in the treated plots suffered badly and the stand was thus poor. The yield of grain and straw was thus reduced by half. There was little difference in the growth of weeds between the treated and control plots and the weed population itself was negligible in both the cases.

6. Miscellaneous

(i) *Permanent plot.*—From practical considerations it is useful to inquire about the limits of crop production and the factors that set these limits under a given environment. For such a study records of yield alone are not helpful; these must be supplemented by regular periodical observations on the growth of the crop. A plot was, therefore, laid down with two varieties of wheat, N.P. 165 and N.P. 122. Plant samples were collected at weekly intervals for estimation of dry matter and chemical analysis. A schedule of rotation with legume in the *kharif* and standard cultivation practice will be strictly adhered to. This will be a long-term investigation.

(ii) *Shaftal.*—Shaftal (Persian clover-*Trifolium resupinatum*, L.) developed reddening of leaves during March-April in 1946 and observations were therefore recorded in the 1946-47 crop throughout the life-cycle with a view to the aetiology of reddening. Reddening of tips of leaves appeared about three weeks after sowing in (October) and during December the symptoms were on an increase. Millon's test for protein and iodine test for starch showed lower protein content and higher starch content in the affected leaves. Evidently there appeared to be some disturbance in the nitrogen metabolism. The new leaves produced later were however free from these symptoms and the crop made good growth. With the onset of flowering the symptoms re-appeared. After flowering and fruiting leaves usually suffer from nitrogen deficiency and it is quite likely that the leaves of shaftal developed autocyanin pigments as a result of nitrogen starvation. The appearance of the symptoms in the early stages might therefore be ascribed to nitrogen deficiency resulting from restricted nodule formation. It may be noted that the plots were not manured with nitrogen.

(iii) *Wheat after Maize.*—Wheat was grown in pots in which Maize was grown during the *kharif*. The wheat plants in "maize" pots were distinctly backward compared to controls in the early stages but later they made up and yielded as well as the controls.

PLANT INTRODUCTION

1. Plant exploration

Small areas in the plains of U.P. and C.P. and in the Himalayan ranges were surveyed and seeds and plant specimens of important plants of *Leguminosae*, *Malvaceae*, *Solanaceae*, *Graminae* and other families were collected. The collection of leguminous seeds consisted of species of *Phaseolus*, *Dolichos*, *Medicago*, *Trigonella*, *Lespedeza*, *Desmodium*, *Crotalaria*, *Indigofera*, *Alysicarpus*, etc. Seeds were also collected of certain wild Himalayan medicinal plants.

A start was made in the collection of information available in the literature on the economic plants, both wild and cultivated, of foreign countries. Short lists of important foreign plant material worth importing were forwarded to some of the organizations abroad. The receipts of exotic material during the year, which was mainly from the U.S.A., Canada, England, Australia, Africa, Kenya, China, Philippines, etc., consisted of varieties of cereals, fodder grasses, wild relatives of wheat, legumes such as soyabeans, *Lespedeza*, *Pueraria*, lupins, various kinds of fodder and vegetable beans, tomatoes, brinjal, cinchona, castor, flax and a few ornamental and hedge plants. A part of this material was supplied to certain of the provinces and states for trial under different soils and climatic conditions. The imported material and the indigenous material collected during the surveys was grown at Delhi and observations taken on germination of seed, adaptability, growth, flowering, fruiting, disease-resistance, resistance to heat, cold, and drought and other agronomic characters.

MISCELLANEOUS

1. Seed-setting in bersoom

Five varieties were grown for studies on seed-setting at Delhi and Pusa. Observations recorded on flowering, bee visits and seed-setting were in conformity with the results of the previous years.

2. Performance tests of vegetables

The work taken up is preliminary to the setting up of a Central Seed Testing Station which the Government of India have under consideration. 512 samples of 22 vegetables received from the United States of America and provinces and states in India were tested for germination, purity and field performance with particular reference to productivity and disease resistance.

3. Crop outturns and seed distribution

The yields of the most of the crops were normal. Rust was severe in wheat and it affected the yields.

The seed of the improved varieties was distributed mainly to the provincial and State Agriculture Departments. There was a heavy demand for the N.P. wheats, only a small part of which could be met.

Tables indicating acre-yields of different crops and the quantities of the seed of the N.P. varieties distributed are given below,

Statement of yield of crops in the Division of Botany during 1946-47.

Crop.	Plot No.	Area in acres.	Outturn of grain in lb.		Remarks.
			Actual.	per acre.	
<i>Wheat.</i>					
N. P. 4	14	1.00	1,919.3	1,919.3	
<i>Oats.</i>					
N. P. 1	6	0.50	693.3	1,386.6	} Sown late (30-11-46) after harvest of <i>Mung</i> and <i>Urid</i> .
N. P. 2	6	0.50	567.8	1,135.6	
N. P. Hyb. 1	32	0.65	1,604.6	2,468.6	
N. P. Hyb. 3	32	0.65	1,493.5	2,927.6	
N. P. X-27	1	0.28	936.0	3,415.4	
<i>Barley.</i>					
N. P. 13	49	0.60	1,830.9	3,051.5	
<i>Gram.</i>					
N. P. 17	52	0.50	557.5	1,115.0	
N. P. 25	52	0.50	750.9	1,501.8	
N. P. 53	53	1.00	1,536.7	1,536.7	
N. P. 58	19	0.25	164.6	658.4	Sown late (8-11-46) after harvest of <i>Jowar</i> .
<i>Peas.</i>					
N. P. 29	21	0.33	841.4	2,524.2	Seeds damaged by insects in the field.
<i>Maize</i>	22	1.00	1,602.5	1,602.5	

Statement showing the quantity of seed distributed from the Division of Botany during 1946-47.

Crop.	Quantity distributed.	Crop.	Quantity distributed.
<i>Wheat.</i>	lb.	<i>Peas.</i>	lb.
N. P. 4	1,965·0	N. P. 29	366·0
N. P. 80·5	114·0	Chillies	..
N. P. 111	220·0	N. P. 34	0·25
N. P. 121	560·0	N. P. 41	0·25
N. P. 021	333·0	N. P. 46	0·25
N. P. 125	601·0	N. P. 51	0·25
N. P. 126	241·0		
N. P. 165	205·0		
		<i>Hibiscus.</i>	
<i>Oats.</i>		N. P. 3	1·0
N. P. 1	22·0	N. P. Sab. 5	1·0
N. P. 2	1·0		
N. P. X-27	62·0		
N. P. Hyb. 1	2·0		
N. P. Hyb. 3	248·0		
<i>Barley.</i>			
N. P. 13	844·0		
<i>Gram.</i>			
N. P. 17	84·0		
N. P. 25	412·0		
N. P. 28	7·0		
N. P. 53	892·0		
N. P. 58	202·0		

III. ADVISORY

As in previous years, a large number of enquiries were received from all over the country and from abroad regarding refereeing of papers for publication varieties of crops, exchange of seeds and other material methods of breeding and cultivation, economic wild plants including identification of plant specimen, etc., and the information asked for was supplied. The enquiries may be classified as follows:—

Nature of Enquiries.	Number.
1. Notes on particular topics and comments on reports, etc.	4
2. Vernacular and Botanical names, methods of cultivation, sources of seed supply and other miscellaneous information	43
3. Seed samples received	4 sources.
4. Plant specimens identified	About 25
5. Seed samples supplied	7 correspondents.
6. Plant specimens sent	3
7. References to literature supplied to correspondents	5 correspondents.

IV. PROGRAMME OF WORK (1947-48)

1. Studies in the improvement of Indian wheat (*Triticum* spp.) will be continued.
2. The work reported on breeding crop plants for disease resistance and other qualities will be continued.
3. The genetical investigations reported will be continued.
4. Cytogenetical studies in the Brassicæ will be continued.
5. Work on the items reported under Fundamental Cytogenetical Research will be continued.
6. Studies on drought resistance in wheat will be continued.
7. Investigations on plant hormones and chemical regulation of growth and development will be continued.
8. Investigations on physiological analysis of factors influencing yield will be developed.
9. Studies in hybrid vigour, with special reference to maize and on the problem of seed-setting in berseem will be continued.
10. The miscellaneous crop collection will be maintained and further studied.

REPORT OF THE SUGARCANE EXPERT

I. INTRODUCTION

This report includes the work carried on at the Sugarcane Breeding Station, Coimbatore, as also the main results of research in three schemes connected with the Station. These schemes are: (i) Sugarcane Sub-station, Karnal, (ii) Scheme for Research on the Physiology of Sugarcane, Coimbatore, and (iii) *Saccharum spontaneum* Expedition Scheme. Of these, the Spontaneum Scheme is a new scheme sanctioned from April 1946. All these three schemes are financed by the Indian Central Sugarcane Committee.

II. SUGARCANE BREEDING

(a) Hybridisation and Selection.

The rainfall during the season was above the average and greatly helped flowering. Many varieties flowered profusely and earlier than normal. Most of the programmed crosses were successfully effected. During the year over 130 crosses were effected in addition to over 200 for genetical studies.

The bulk scale economic crosses.—There were seven in number, viz., (1) Co. 443 $\times$ Co. 453, (2) Co. 603 $\times$ S.O. 63/32, (3) Co. 349 $\times$ Co. 244, (4) Co. 349 $\times$ Co. 617, (5) Co. 421 $\times$ Co. 617, (6) Co. 508 $\times$ Co. 301, and (7) P.O.J. 2878 $\times$ Co. 453. Of these Co. 349 $\times$ Co. 244 is a repetition of last year as the desired number of seedlings were not obtained last season. The cross Co. 508 $\times$ Co. 301 was done with a view to get seedlings with early sugar and good vigour in addition to a solid core.

Semi-bulk scale crosses.—In this, 15 crosses were done, the more important of which are: (1) Co. 349 $\times$ Co. 557, (2) Co. 508 $\times$ Co. 313, (3) Co. 508 $\times$ Co. 453, (4) Co. 534 $\times$ Co. 453, (5) Co. 630 $\times$ Co. 453, (6) P. 2607 $\times$ Co. 644, (7) P. 3247 $\times$ Co. 440, (8) P. 4626 $\times$ Co. 644 and (9) P. 4626 $\times$ S.O. 201/1. In the above crosses two new parents are employed, viz., Co. 534 (Co. 349 $\times$ Co. 312) and Co. 557 (Co. 508 $\times$ Co. 313), the former to introduce Co. 349 parentage and the latter for obtaining early types. P. 4626 was employed to see if non-pithy canes could be got out of this variety. A large number of experimental crosses were effected to assess the value of the varieties employed as parents and in this Co. 449 has found a prominent place which is likely to give early maturing seedlings.

Sorghum crosses.—These were continued during the year and the sweet sorghums figure prominently. These were used mostly on P.O.J. 213 and P.O.J. 2725, two recognized good female parents. Use was also made of the sorghum seedling Co. 630 in a few crosses as also Co. 356 and Co. 639 (S.O. 851 $\times$ Co. 453).

Bamboo crosses.—Only two varieties of bamboo parentage were utilized for crossing. The varieties were C. 2291 and G. 4938 (Co. 421 $\times$ C. 2291). The latter variety has been found to be a good female parent imparting vigour to the progeny.

Fodder crosses.—For evolving fodder types, the forms of *sorghum halepense*, Guinea grass, Napier grass and the fodder canes Co. 559, Co. 560 and Co. 561 were used in different combinations. In all 11 crosses were effected.

Chewing canes.—Co. 603 which in itself is a soft vigorously growing cane was used as female parent and the pollen of Co. 301, Co. 453, Co. 545 and Co. 617 was dusted on the variety. In addition to these B. 6308 and E.K. 28 were also used as parents in certain crosses.

Nursery, Test Plots and Selections.—Germination was very good this year and especially in the following crosses: (1) P.O.J. 2878 × Co. 213, (2) P.O.J. 2878 × Co. 453, (3) P.O.J. 2878 × Co. 545, (4) Co. 421 × Co. 617, (5) Co. 630 × Co. 557, (6) Co. 443 × Co. 453 and (7) Co. 603 × S.C. 63/32. Most of the crosses with Co. 464 gave poor germination as also *officinarum* crosses in general and P.O.J. 2725 × Sweet *Sorghum*. The seedlings were found to grow vigorously in the crosses in which Co. 453, Co. 557 and Co. 617 had been used as parents.

Over 900 seedlings were selected for one row trial from the second ground nursery. The crosses which deserve repetition are: (1) P.O.J. 2878 × Co. 545, (2) P.O.J. 2725 × Co. 617, (3) Co. 508 × Co. 617, (4) Co. 527 × Co. 285 and (5) Co. 527 × Co. 453. The seedlings in the crosses in which Co. 349 has been used as the female parent lack in vigour besides being pithy. Co. 454 has been behaving as an erratic and unreliable parent and it will not be worthwhile to use it for breeding economic type of seedlings. A few seedlings with *Sorghum halepense* as one of the parents have been isolated, which may prove useful as fodder types.

From the (1946-47) one row test plot over 170 seedlings were selected out of a total of 970 seedlings for the six row trial. A study of the seedlings shows that Co. 508 gives rich early types but they are thin-stalked. The progeny of P.O.J. 2878 × Co. 301 was vigorous and thick. Co. 545 gives good seedlings when crossed with Co. 508 and P.O.J. 2878. The varieties Co. 300, Co. 385 and Co. 618 when used as parents give seedlings of doubtful value.

A total of 151 seedlings was dealt with in the six row test plots. Out of these 15 seedlings were raised to the status of Co. canes. Their characteristics and parentage are given elsewhere in this report.

(b) Study of special characteristics.

Early ripening canes.—Co. 508 has again proved its usefulness as a parent from which early ripening seedlings can be bred. The following crosses also have been found to give early type of canes: (1) Co. 349 × Co. 301, (2) Co. 508 × Co. 453, (3) Co. 508 × Co. 545, (4) Co. 351 × Co. 545 and (5) Co. 349 × Sweet *Sorghum*. In addition to these one seedling of P.O.J. 2725 × C. 1051 (seedling of Burma *spontaneum*) shows promise as an early type.

Late ripening canes.—Two crosses, viz., P.O.J. 2878 × Co. 301 and Co. 421 × Co. 301 give seedlings which are late ripeners.

Pithy and non-pithy canes.—In addition to Co. 301 and Co. 508 which transmit their character of solid core to the progeny, Co. 244 has been found useful. In the crosses with Co. 244 as the male parent and Co. 349 and Co. 421 as female parents, the percentage of pithy seedlings was 50 per cent. in the former and 45 per cent. in the latter. In combinations like P.O.J. 2878 × Co. 453, P.O.J. 2878 × Co. 545 and Co. 527 × Co. 453, 80 to 90 per cent. of the seedlings were found to be pithy. These parents should always be used with caution when high yielding economic types are aimed at.

Fodder canes.—A few suitable Co. canes, some promising G. numbers and the fodder types Co. 559, Co. 560 and Co. 561 were given a row each in three replications alongside Guinea grass and Napier grass which were kept as standards. The following varieties were found to be quite good and better than Guinea grass, though in actual yield Napier grass beat all the others. The varieties tested are Co. 605, Co. 617, Co. 285, Co. 619, Co. 537 and G. 4545. It is proposed to study the nutritive value of these fodder types during the next season.

Chewing canes.—One cane, Co. 652, was released during the year, which may be of use as a chewing cane.

III. INVESTIGATIONS

(a) *Taxonomic Studies.*

(i) *Anatomy.*—Anatomical studies of the different species of *Saccharum* and allied genera have been of help as an aid to classification of the genera. The conclusions arrived at by such studies are found to be in accord with the classification based on morphological study, according to which four genera are recognisable, viz., (1) *Saccharum*, (2) *Erianthus*, (3) *Sclerostachya* and (4) *Narenga*. Differences are noticed among the genera in the nature and arrangement of the vascular bundles in the leaf, *Saccharum* and *Narenga* having three types of bundles, *Erianthus* four and *Sclerostachya* one. The genus *Narenga* can be differentiated from *Saccharum* by the prominently ribbed upper surface and the presence of long one celled hairs. The species of *Erianthus* are characterised by cuticular papillae in the lower epidermis. The ratio of the number of stomata in the lower and upper epidermis is noticed to be characteristic of each genus, being 1:1 in *Sclerostachya*, 2:1 in *Saccharum* and *Narenga* and 3:1 in *Erianthus*. The epidermal pattern of the stem is also of use in the separation of the genera.

(ii) *Standard for description and identification of varieties.*—Morphological studies undertaken with a view to fixing up stable and dependable characters for description and identification of cane varieties, as also the exact place for selection of such characters, have given an indication of the extent of variability of the different characters and those on which reliance can be placed for description of varieties. The important characters useful in the identification of varieties are: (1) the colour of the basal internodes, (2) the presence and amount of bloom, (3) the presence of bud grooves, growth cracks and weather markings, (4) the nature of ligule and auricle, (5) the presence of bloom and hairiness of sheath, (6) the size, shape and origin of bud and (7) the size of the leaf under constant conditions. These characters have been found to be fairly constant and hence fit for comparative descriptive study. Regarding the exact portion of the cane for description, the topmost dry leaf joint has been found to be the best for characters of node, internode and bud. For auricle and ligule, the third topmost fully unfurled leaf is the best for comparative purposes. Fully mature crop ten months old is good for description and identification of cane varieties.

(iii) *Description of Co. canes.*—All the important and popular Co. canes were described and a key drawn up with a view to be of use in the preparation of the Bulletin on Co. canes.

(b) *Chemical studies.*

(i) *Root Studies.*—Preliminary studies on the sett-root development in sugarcane as influenced by the Hydrogen-ion Concentration and the salt content (NaCl) of the culture medium have indicated that (1) the optimum pH for vigorous root growth is 5.0, (2) there is another optimum at pH 9.0 where both the varieties tried, viz., Co. 432 and Poovan showed good root growth, (3) Co. 432 is more tolerant to variation in pH both on the acid alkaline side than Poovan. As regards the effect of salt concentration (NaCl) it was found that 0.10 per cent. concentration of sodium chloride had adverse effect on the root growth in all the three varieties tried, viz., Co. 419, Co. 432 and Red Mauritius, Red Mauritius suffering the most. With 0.05 per cent. salt concentration both Co. 419 and Co. 432 showed vigorous root growth while in the case of Red Mauritius there was a set-back in root growth as compared to the control.

(ii) *Standard plot.*—To get fuller data on the complete chemical composition of the juice including those non-sugar constituents which affect the manufacturing qualities as also the growth characteristics of the important Co. seedlings and all the new Co. seedlings from Co. 600 onwards a special plot has been laid at the Sugarcane

Breeding Station and 83 varieties have been planted, two rows, each repeated three times. These will be analysed in November, January and March.

To find out the effect of planting in different months of the year on the maturity and growth of sugarcane, bi-monthly planting (April, June, August, October, December and February) of the varieties Co. 419, Co. 421 and Co. 449 has been carried out at East Chitrai Chavadi. The analysis of the April, June and August plantings so far done indicated the definite superiority of April planting over June and August planting as far as early ripening was considered.

(c) Cytogenetical Studies.

Eighteen types of *Erianthus* species in the collections at Coimbatore were examined and were found to fall in four groups according to chromosome numbers, viz., $2n=20$, 30, 40 and 60. Hybridisation between plants of these groups is programmed for the analysis of chromosome complements and classification.

Chromosome counts of 36 direct hybrids involving 3 types of *Saccharum officinarum* and *Saccharum spontaneum* (Coimbatore) gave $2n=112$ in all cases. This indicates that only unreduced gametes in *Saccharum officinarum* (i.e., $2n=80$) function though both reduced and unreduced gametes are produced. A number of reciprocal crosses are made to isolate hybrids with $2n=72$.

Among the intergeneric crosses made last year with *Saccharum spontaneum* as mother and *Sclerostachya*, *Narenga*, *Erianthus* and *Sorghum halepense* as male parents, it is found that hybrid vigour is very marked particularly in *Saccharum spontaneum* and *Sclerostachya* hybrids. All the hybrids are characterised by imperfect floral organs.

The meiosis of Vellai $\times$ *Sclerostachya* and their back crosses were studied in detail and hybrids of 3rd and 4th back crosses were found to be specially important.

Back crossing with the wild species was resorted to break up the amphidiploid constitution of the hybrids with the object of (1) finding the relationship of the wild species with *Saccharum officinarum* and (2) if related, to combine the characters of wild species with those of *Saccharum officinarum*. Both these objects were achieved in *Saccharum officinarum* and *Sclerostachya* hybrids. It is found that *Saccharum officinarum* has two basic complements of $n=5$ each and one of these is common to *Sclerostachya*. Plants combining some of the characters of *Sclerostachya* and *Saccharum officinarum* are obtained from the selfs of 3rd back cross hybrids $2n=50$.

(d) Plant Physiological Studies.

The photoperiodic treatments with a short day of 2 hours, i.e., 22 hours darkness for a period of 60 days prior to the commencement of flowering season induced flowering in *Saccharum spontaneum* (Gerahbon) a variety which does not flower in Coimbatore.

The same treatment given to the potted tops of the flowering variety *Saccharum spontaneum* (Soraparai 270) resulted in considerable delay in the time of flowering. With normal daylight the variety flowered in the 3rd week of November. With 2-hour day treatments for periods of 15 days, 30 days, 45 days and 60 days the variety flowered in the 2nd week of December, 3rd week of December, first week of January and 4th week of January respectively. The variety Soraparai 270 growing in the field was subjected to 9-hour, 10-hour, 11-hour, 13-hour and 14-hour day lengths including normal day. With 10-hour and 13-hour day lengths it flowered 20 days later than the control and with 9-hour and 14-hour treatments, 35 days later than the control. With 11-hour day it flowered 46 days earlier than the control and 75 days earlier than 9-hour and 14-hour day lengths. Thus by carefully adjusting the day length conditions, the flowering range of this variety was extended to a period of four months. The usual duration of flowering in cane varieties does not exceed ten to fifteen days.

In the irrigation experiments two non-flowering forms G. 3011 and *Saccharum spontaneum* Cerahben flowered profusely when subjected to increase irrigation and low nitrogen supply.

Studies in the chemical composition of flowering and non-flowering cane varieties Co. 421 and Co. 442 with regard to their carbohydrate-nitrogen constituents were continued and the analysis of the 1943 and 1944 samples were completed. The results do not indicate any marked difference in the two varieties except in the soluble carbohydrate content and in the total carbohydrate nitrogen ratio. The soluble carbohydrates in both the years maintain a higher level throughout the growth period in the flowering variety Co. 421 as compared to Co. 442. The carbohydrate nitrogen ratio is consistently higher in Co. 421 as compared to Co. 442.

IV. SUGARCANE SUB-STATION, KARNAL

The total number of varieties planted for 1946-47 season was 726 consisting of 100 Co. canes, 124 North Indian canes, 90 exotics, 80 wild *Saccharum* and allied genera, 84 other varieties and 18 Co. K. seedlings.

The reaction of parent canes to North Indian climatic conditions was studied in detail this year. Among the parent canes Co. 205, Co. 223, Co. 244, Co. 245, Co. 290, Co. 312, Co. 331, Co. 419, Co. 421, Co. 453, Kassar, S.C. 351 and C. 1051, stand out prominently with regard to quick and good germination, early cane formation and adaptability to the adverse conditions prevailing in North India. A few more varieties were picked out from the live herbarium whose good performance justify their being included in the parent list.

The morphological descriptions of the previous years were checked and some new varieties were described. Notes were also recorded on (1) the angle which the shoot makes just after germination and (2) curvature of leaves as a help in identification in the early stages of growth.

Special attention was paid to studying the flowering of the wild *Saccharum* as these figure prominently in the breeding work. The pollen viability and the anther dehiscence was studied in particular. No anatomical or cytological studies were made. Physiological experiments conducted in the shape of photoperiodism, irrigation and endeavouring to induce seven non-flowering varieties at Karnal to flower by the Sugarcane Physiologist, Coimbatore, gave encouraging results. Three out of seven varieties flowered in the daily and alternate day irrigation plots without manure.

Tours were undertaken to Shahjahanpur, Pusa, Peshawar and Coimbatore to describe the popular varieties and also to check up the varieties with the labels with a view to study whether the varieties were grown true to type. While describing canes, all variations in girth, colouration, etc., have been noted as additional help in identification of the varieties.

V. SPONTANEUM EXPEDITION SCHEME

The debt that cane breeding in India owes to *Saccharum spontaneum* L. is well known. The Coimbatore Station was the first deliberately to use *spontaneum* in its breeding and immediately reaped the benefit in the very first batch of Co. canes in 1888 when Co. 205 (a direct or F₁ seedling of *Saccharum spontaneum*) proved itself drought and frost resistant in the Punjab with its well-known extremes of climate. Since then *spontaneum* has been used directly in "dilution" so much so that there is practically no Co. seedling which does not contain some percentage of *spontaneum* in its parentage.

The Coimbatore Station already possesses a good collection of the wild *Saccharum*. Recent work at the Station on the cytological aspect has given interesting data on the chromosome numbers of the various forms. It is very desirable that further additions are made to this collection. At present the various forms have been collected from different places at random. A systematic and organized effort will be made to collect the forms intensively, from each area including the hilly tracts.

The Scheme of collecting *Saccharum spontaneum* and allied genera has been sanctioned by the Indian Central Sugarcane Committee for a period of five years from 1st April, 1946. The Botanist and the Assistant Botanist of this Scheme have not yet joined duty. The only staff so far appointed are (1) Senior Assistant, (2) Artist, Photographer, who have joined at Karnal and have been engaged in getting acquainted with the wild *Saccharum* collection at the sub-station. Line drawings of certain important *spontaneums* were recorded by the Artist.

VI. DISTRIBUTION

(a) *As canes (inland)*.—A total of 103 parcels comprising 99 varieties were despatched to 38 places in India for trial.

Foreign.—(1) Twenty-two varieties were sent to the Director, National Agricultural Extension Commission, Ministry of Agriculture and Forestry, Nanking, China, through the External Affairs Department, Government of India.

(2) Two sugarcane $\times$ *Sorghum* hybrids were sent to Prof. Edga Taschdjian, Head of the Section of Plant Production, Department of Agriculture, The Catholic University, Peiking, China, through the External Affairs Department, Government of India.

(3) Under the instruction of the Government of India, the varieties Co. 321 and Co. 432 were sent to the Consul for Iraq, Bombay.

(b) *As seeds*—

(i) To Shahjahanpur: (1) Co. 453 $\times$ Co. 557, (2) Co. 464 $\times$ Co. 313, (3) Co. 464 $\times$ Co. 557, (4) Co. 527 $\times$ Co. 313, (5) Co. 527 $\times$ Co. 453 and (6) Co. 527 $\times$ Co. 508.

(ii) To Lyallpur: (1) Co. 312 $\times$ Co. 285, (2) Co. 312 $\times$ Co. 313, (3) Co. 312 $\times$ Co. 453, (4) Co. 464 $\times$ Co. 313 and (5) P.O.J. 2878 $\times$ Co. 313.

(c) The parentage and general characteristics of Co. seedlings distributed to various Provincial Testing Stations during the year are given below:—

Serial No.	Co. No.	Parentage.	General characteristics.
1	Co. 645	Co. 221 $\times$ F.H.R.	A medium cane of satisfactory yield and vigour.
2	Co. 646	Co. 213 $\times$ [(Vollai $\times$ Narenga porphyrocoma) $\times$ Co. 205].	A cane of good vigour, sparse flowerer.
3	Co. 647	Co. 421 $\times$ Co. 312	Vigorous grower and good tillerer; somewhat late in ripening.
4	Co. 648	Co. 421 $\times$ Co. 312	Same parentage as Co. 647 but with better sucrose.
5	Co. 649	Co. 508 $\times$ Uba Marot	A very vigorous mid-season cane with moderate sucrose.
6	Co. 650	P.O.J. 2878 $\times$ Co. 312	A medium cane of satisfactory habit and sucrose.
7	Co. 651	Co. 345 $\times$ Co. 545	Medium thick, approaching Co. 419 class. Sparse flowerer.
8	Co. 652	[Co. 349 $\times$ (P.O.J. 2725 $\times$ Imperata sp.)] $\times$ Co. 605.	Thick cane, satisfactory yield, but moderate sucrose.
9	Co. 653	P.O.J. 2725 $\times$ Co. 301	Of possible utility as chewing cane. Moderate height and yield but satisfactory sucrose and relatively less pith formation.
10	Co. 654	P.O.J. 2727 $\times$ Co. 419	A vigorous mid-season cane.
11	Co. 655	Co. 349 $\times$ Co. 453	A Co. 419 class of cane.
12	Co. 656	Co. 421 $\times$ Co. 453	A Co. 421 class of cane.
13	Co. 657	Co. 453 $\times$ Co. 440	A Co. 313 class of cane.
14	Co. 658	Co. 443 $\times$ Co. 605	A heavy yielder.
15	Co. 659	Co. 603 $\times$ (P.O.J. 2725 $\times$ Imperata sp.)	An early maturing type.

VII. PROGRAMME OF WORK (1947-48)

Breeding with particular emphasis on specialised characters as "early" and "late" maturity, disease resistance, non-pithy character of the stem and chewing quality. Attention will also be paid to evolving fodder canes.

Cyto-genetical studies with a view to investigating the mode of inheritance of characters in *Saccharum* and allied genera.

Physiological studies on the chemical composition of flowering and non-flowering varieties and the initiation of reproductive phase in non-flowering canes by photoperiod treatments and chemicals.

The relationship of anatomical and other characters to disease, drought and frost resistance and their inheritance in cane hybrids.

Determination of albuminoids, colloids, etc., in the seedling canes before they are released from Coimbatore.

REPORT OF THE DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

I. RESEARCH AND INVESTIGATIONS

Soil and Agricultural Chemistry

1. *New Russell Experiments.*—Comparison in field experiments of the relative values of nitrogen in green manure, farmyard manure, compost, oilcake and ammonium sulphate, estimating the recovery of nitrogen by the crop and the changes in moisture, ammonia and nitrate contents of the soils of different plots.

Soil samples from the different plots were examined for ammonia and nitrate at two intervals once at the time of sowing and again after harvest. The wheat crop grown on these plots was analysed for nitrogen to study its recovery. The results are set forth in the following tables:—

Soil Composition of New Russell Plots, 1946-47.

At sowing of Wheat No. 1 and 2, 1946.					After harvest of wheat April 14, 1947.				
Treatment.	Field moisture per cent.	Per cent. Mgm. N as ammonia.	Per cent. Mgm. as Nitrate.	Per cent. Mgm. as Nitrate.	Field moisture per cent.	Per cent. Mgm. N as Nitrate.	Per cent. C.	Per cent. N.	C/N.
A. G. M. with sunnhemp .	9.98	0.096	0.0066	1.189	3.28	0.025	0.395	0.071	5.6
B. G. M. with cowpeas .	10.14	0.108	0.0050	1.204	3.06	0.029	0.390	0.075	5.2
C. Rape cake at 40 lbs. N per acre.	10.07	0.178	0.0101	1.414	2.62	0.031	0.312	0.060	5.2
D. Castor cake at 40 lbs. N per acre.		0.197	0.0092	1.766	2.25	0.026	0.335	0.060	5.6
E. F. Y. M. at 40 lbs. N per acre.	9.93	0.113	0.0058	1.238	2.58	0.024	0.354	0.061	5.8
F. Compost at 40 lbs. N per acre.	10.79	0.136	0.0062	1.508	2.04	0.034	0.370	0.067	5.5
G. Am_2SO_4 at 40 lbs. N per acre.	10.57	0.285	0.0081	1.224	2.55	0.053	0.392	0.050	7.8
H. No manure . . .	10.25	0.149	0.0045	1.192	2.32	0.019	0.368	0.065	5.7

It is evident from the above table that at the time of sowing wheat, appreciable amounts of nitrate were formed in the soil especially in those plots to which oilcakes and compost were applied. After the harvest of wheat, however, the presence of nitrate in all the plots was almost negligible and the amount of nitrogen was the lowest in the ammonium sulphate plot which was less than even that of the no manure plot.

The variations in the nitrogen status of the different plots under different manurial treatments are not reflected in their crop yields; the differences in yields of grain

between the treated plots were not significant. The recovery of nitrogen by the wheat crop in 1945-46 and 1946-47 is shown in the following tables:—

Wheat 1945-46 (New Russell).

Wheat crop recoveries of N in crop.

Treatment.	N ₂ in crop in lbs. per plot.	Difference from control.	Difference from control in lbs. per acre.	Per cent. recovery of N.
A. Green manure with sunnhemp	1·568	0·279	6·14	15·35
B. Green manure with cowpeas	1·548	0·259	5·70	14·25
C. Rape cake at 40 lbs. N.	1·824	0·535	11·77	29·43
D. Castor cake at 40 lbs. N.	1·593	0·264	5·81	14·52
E. F. Y. M. at 40 lbs. N.	1·506	0·217	4·77	11·94
F. Compost at 40 lbs. N.	1·664	0·375	8·25	20·63
G. Am. sulphate at 40 lbs. N.	2·158	0·869	19·12	47·80
H. No manure	1·289	..	..	..

New Russell Experiments, 1946-47.

Wheat crop recoveries of N in crop.

Treatment.	N in the total crop in lb. per plot.	Difference from control of N in lb. per plot.	Difference from control of N in lb. per acre.	Per cent. recovery.
A. Green manure with sunnhemp	1·81	— 0·12	—2·64	—6·6
B. Green manure with cowpeas	1·94	0·01	0·22	0·55
C. Rape cake at 40 lbs. N per acre	2·46	0·53	11·66	29·15
D. Castor cake at 40 lbs. N per acre	2·34	0·41	9·02	22·55
E. F. Y. M. at 40 lbs. N per acre	2·01	0·08	1·76	4·4
F. Compost at 40 lbs. N per acre	2·45	0·52	11·44	28·60
G. Am ₂ SO ₄ at 40 lbs. N per acre	2·68	0·75	16·5	41·25
H. No manure	1·93	..	..	..

Old Russell plots.—The grain and straw samples of wheat crop 1945-46 were analysed for N and the amount of nitrogen removed by the crop and the per cent. recovery of nitrogen added in the manure were calculated. The data were given in the following table.

It was observed that maximum nitrogen recovery was obtained in the case of rape cake treatment and complete artificials (N + P + K) treatment. The addition of nitrogen in available form (Sulphate of ammonia) to compost or F.Y.M. enhanced the recoveries of N. The addition of compost or F.Y.M. either singly or together with P + K gave very low recoveries of nitrogen.

Evaluation of recoveries of added nitrogen 1945-46.

From the dry weight and nitrogen percentage of grain and bhusa the total nitrogen content of the crop under various treatment were calculated.

Treatment.	N in the crop in lbs.	Difference from control.	N in added manures.	% Recoveries.
A. No manure	0.6030	Nil.	0.65433	..
B. F. Y. M.	0.6231	0.201	„	3.07
C. Activated sludge	0.7361	0.1331	„	20.34
D. Mustard cake	0.9204	0.3174	„	48.52
E. B + P + K	0.5271	0.0759	„	0 (negative)
F. C + P + K	0.6218	0.0187	„	28.64
G. D + P + K	0.7475	0.1445	„	22.09
H. Compost	0.6382	0.0352	„	5.38
I. Compost + N + P	0.6838	0.0808	„	12.35
J. F.Y. M + N + P	0.7488	0.1458	„	22.28
K. F. Y. M	0.8015	0.1985	1.30866	15.17
L. N + P + K	0.9006	0.2976	0.65433	45.49

To study to what level berseem treated with phosphatic fertilizers and followed by guar for three years builds up soil fertility as judged by their residual effect on subsequent yields of wheat and maize. (Series III).

Manurial treatments applied per acre to berseem were as follows. Experiments were started in 1945-46 *rabi*.

Nil	A. No manure.
50P	B. Superphosphate at 50 lb. P_2O_5 .
100P	C „ 100 „
50P + 80K	D „ 50 „ + K_2SO_4 at 80 lb. K_2O .
100P + 80K	E „ 100 „ „

There were 5 treatments with 6 replications of each in randomised blocks.

Before the application of fertilizers to berseem in 1946. Soil samples were taken from each plot for examining nitrogen, total and available P and K, and aggregate composition. The analysis are in progress.

Four cuttings of berseem were taken till the harvesting time and analysed for N, P and C_a. The total crop and the recovery by the crop of these constituents from the soil and applied fertilizers are shown in the following table:—

Yield of green berseem plants in lb. per acre and recovery of certain minerals in the crop, 1946-47. Average of 6 replications.

Treatment per acre.		Berseen plants lb. per acre.	Difference in yield from control.	N in total crop in lb. per acre.	P ₂ O ₅ in total crop in lb. per acre.	Difference from control of P ₂ O ₅ in lb. per acre.	% Recovery of added P ₂ O ₅ .	C.O in total crop lb. per acre.	Difference from control of C.O in lb. per acre.
Nil.	A. No manure (control) .	10604	—	63.78	9.58	—	—	61.12	—
50 P.	B. Super at 50 lb. P ₂ O ₅ .	11995	1391	61.25	13.11	3.53	7.06	71.27	10.15
100 P.	C. Super at 100 lb. P ₂ O ₅ .	12056	1452	64.61	16.98	7.60	7.40	68.64	7.52
50P+80 K.	D. Super at 50 lb. P ₂ O ₅ + K ₂ SO ₄ at 80 lb. K ₂ O.	10208	-396	60.26	11.83	2.25	4.50	60.48	-1.14
100P+80 K.	E. Super at 100 lb. P ₂ O ₅ + K ₂ SO ₄ at 80 lb. K ₂ O.	11390	786	63.99	15.98	6.40	6.40	68.95	7.83

It is evident from the table that the application of phosphatic fertilizers had increased the yield of berseem but there is little difference in yield from the applications of 50 and 100 lb. P₂O₅ per acre. The addition of potassic fertilizers to superphosphate has lowered the crop yield. The recovery of P₂O₅ by the berseem crop from the application of 50 and 100 lb. of P₂O₅ per acre has been almost of the same order. On the other hand, an addition of potassic fertilizers to superphosphatic has not only depressed the crop yield, but also lowered the P₂O₅ recovery by the crop. Potassium fertilizers also appear to have lowered uptake of calcium by the plants.

To study the effect of heavy doses of complete fertilizers (N, P and K) without legumes in building up soil fertility and maintaining crop yields of wheat and maize for comparison with series I, II and III above. (Series IV.)

Manurial treatments applied per acre to wheat were as follows:—

Nil. A. No manure.

60N+100P+80K B. Am₂SO₄ at 60 lb. N+Super at 100 lb. P₂O₅ +
K₂SO₄ at 80 lb. K₂O.

60N+100P+80K C. F. Y. M. at 60 lb. N+Super and K₂SO₄ as in
B, making allowance for P₂O₅ and K₂O in
F. Y. M.

60N+100P+80K D. Castor cake at 60 lb. N+Super and K₂SO₄ as
in B. Making allowance for P₂O₅ and K₂O
in the castor cake.

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indicative of their availability according to the different characteristics of the soils examined.

Investigations into the methods of soil analysis.

The analytical methods for Boron, Zinc and Copper determinations have been standardised. The method of Berger and Truog using quin-alizarin was found best suited for Boron. The estimations of Zinc by Dithizone method and copper by Diethyl-dithio-carbonate method were found satisfactory.

(ii) Soil Fertility.

Indicator Plant Studies.—Reddening of berseem and shaftal plants in the field was observed in some plots where phosphatic fertilisers were not applied and the possibility of using these plants as indicator plants for determining P_2O_5 deficiencies in soil was examined. These two crops and another legume lucerne and a non-legume rape were tried in pot culture experiments using unmanured soil (Soil I) from I. A. R. I. Farm where phosphatic fertiliser experiments are in progress. This soil was analysed for total N and NO_3-N , total and available P_2O_5 and K_2O . The available P_2O_5 content was 0.026 per cent. The treatments in the Pot-culture experiments consisted of (1) no manure, (2) ammonium nitrate at 20 lbs. N and sulphate of potash at 50 lbs. K_2O and (3) to (7) Superphosphate at 50, 100, 150 and 250 lbs. of P_2O_5 per acre along with a basal dressing of treatment (2). Studies with rape crop showed that maximum response was obtained with 100 lbs. and 150 lbs. P_2O_5 per acre, the growth with these two treatments being equal. There was a gradual fall with further increases in P_2O_5 doses. With berseem, while no visible deficiency symptoms were observed, definite increase in yields were obtained with an addition of 150 lbs. P_2O_5 per acre and the yield due to 150, 200 and 250 lbs. P_2O_5 per acre did not differ appreciably. In another experiment conducted during the same period, with another soil (Soil Ia) containing an available P_2O_5 content of 0.11 per cent. reddening of leaves, in some cases reddening of the entire plant, was observed during the first two cuttings in the unmanured soil while the plants growing on soil treated with super were healthy and did not show any of these symptoms.

With lucerne and shaftal maximum yields were obtained when super was applied at 50 lbs. and 150 lbs. P_2O_5 per acre respectively. Leaves or stems did not redden in the unmanured pots. In view of high P_2O_5 requirements of berseem, and experience obtained in the experiments regarding presence and absence of reddening of leaves or stems, it appears that berseem may serve as a useful indicator plant in detecting soil deficiencies with respect to P_2O_5 .

With Soil I, and Soil II from top block 1 C plot No. 5 of I. A. R. I. Farm, experiments were conducted with lettuce as an indicator plant. Soil II was also analysed for total and NO_3-N , CaO, total and available P_2O_5 and K_2O .

It was observed that Soil I contained more available nitrogen than soil II and was considered to be capable of supplying enough available N to the crop under field conditions. With respect to P_2O_5 both the soils were considered to be on the border of deficiency. Soil II was considered to be deficient in K_2O while Soil I was not.

With respect to N, the chemical method, Mitscherlich method and indicator plant method using lettuce agreed in showing the relatively larger content of this element in Soil I than in Soil II.

With respect to P_2O_5 Neubauer's method, chemical method and microbiological method (azotobacter plaque technique) showed that the Soil I was richer in available P_2O_5 than Soil II.

Foliar diagnosis studies.—Leaf of wheat plants from the base of the main flowering stem from plots of the New Manurial Series, Pusa, were sampled on four different dates (periods) during the life-cycle of the plant at intervals of two weeks. The composite leaf samples taken from 5 out of 10 replicated plots under each treatment were dried and analysed for the total N, P_2O_5 , K_2O , CaO and MgO content. For interpretation of results obtained, the concepts of intensity of nutrition and N-P-K units (physiological ratio) termed as "Foliar diagnosis indices" were applied. The values obtained for the latter are given below. They were graphically represented by trilinear co-ordinates. Response to fertilisers were interpreted by comparison of (1) intensity of nutrition and (2) N-P-K units of plants receiving these treatments. The data obtained did not show wide variations between treatments.

Under the experimental conditions of the above studies the following broad observations may probably be made. In Pusa soil wheat crop responds to nitrogen fertilisation in general and the highest response is obtained when N is applied in combination with phosphoric acid.

Highest yields are associated with high values for the intensities and with great increase in nitrogen in N-P-K units with N and P well balanced. Low yields were associated with low intensities, low values of N in the N-P-K units with N + P showing no constant relationship. In the present instance the N + P plots gave the highest yield. The leaf sample had a high N content initially and this position was maintained throughout the entire period of sampling. The optimum NPK units for wheat as determined by foliar diagnosis or the N-P-K ratio correlated with best nutrition of the plant under conditions of the experiments in this season were found to be N 66.49— P_2O_5 5.85— K_2O 26.66, the intensity being 6.54.

Phosphorus fixation studies.—The problem was undertaken with a view (1) to determine the rate of P_2O_5 fixed in Delhi soil from different fertilisers, (2) to ascertain the effect of nitrogen carried by some nitrogenous fertilisers in this rate of phosphorus fixation and (3) the extent of P_2O_5 fixed in the period under study. The data obtained by incubating the soils at $32^\circ C$. with 16 per cent. moisture content, with and without ammonium phosphate, superphosphate, super + ammonium sulphate, Super + F. Y. M. all at 460 lbs. P_2O_5 per acre, for 3, 6, 9 and 24 weeks showed that in all cases 200 lbs. of P_2O_5 per acre were fixed in 24 weeks. Among the different fertilisers, during the first 3 weeks maximum phosphate was fixed with ammonium phosphate. The differences narrowed down from 6th week and from 9th week onwards, P_2O_5 from different treatments was fixed to the same extent.

Influence of phosphatic fertilisers and crop composition where legumes are included or excluded from the rotation.

(1) *Lysimeter studies.*—One cycle of rotation, wheat-marwa-wheat, in non-legume rotation and berseem-cowpea-wheat in legume rotation, with the 1st crop in 1945-46 receiving treatments as below was completed. In non-legume rotation the treatments were O, N, P, NP. N was applied at 80 lbs. per acre in the form of sulphate of ammonia and P at 100 lbs. P_2O_5 per acre. In legume rotation the treatments were O and P with same dose as above. The broad findings of these investigations were (1) yield data and mineral recoveries by wheat and berseem crops in 1945-46 in both the rotations showed that the application of both nitrogen and phosphorus was necessary while in the case of berseem the application of super alone at 100 lbs. P_2O_5 increased the yields and mineral recoveries. The data obtained emphasised that the soil's major deficiency was nitrogen and unless it was supplied the availability of mineral nutrients for the crop would be very low. But in the case of legume berseem, P alone was effective since the legume could obtain its nitrogen requirements from the atmosphere.

FOLIAR DIAGNOSIS STUDIES OF WHEAT.

The mean values of the intensities of nutrition and of the composition of the NPK units of the respective treatments during the growth cycle.

Treatment.	Plots.	Composition of NPK units (Mean of 3 samplings)			Intensity of nutrition (Mean of 3 samplings).	Mean grain straw plot. Grain lbs.	Yield of and per Straw lbs.
		N	P ₂ O ₅	K ₂ O			
I. (NP) as Ammonium sulphate + Super phosphate.	4, 33, 42, 73 and 86	66.49	6.85	26.66	6.54	14.23	41.78
D. (N) as Ammonium sulphate .	6, 39, 48, 79, 81	68.07	5.43	26.50	6.74	12.83	35.18
J. (NK) as Ammonium sulphate + Potassium sulphate.	9, 31, 50, 72, 83	63.32	6.54	30.14	6.20	12.29	34.11
H. (NPK)	3, 35, 47, 78, 90	60.52	8.05	31.40	6.29	11.81	35.79
B. Farmyard Manure (8,000 lbs. per acre).	1, 37, 45, 80, 84	58.23	9.43	32.65	6.60	11.53	35.67
C. Rape cake (40 lbs. of N per acre).	5, 40, 41, 75, 89	59.99	8.27	31.75	6.62	11.42	36.98
F. (P) as Super	10, 34, 46, 77, 85	61.92	8.66	29.43	6.30	7.63	25.58
A. No Manure	2, 36, 44, 74, 87	60.95	7.63	31.39	6.14	6.76	22.84
G. (PK) as Super + Potassium sulphate.	8, 32, 49, 71, 82	60.11	10.32	29.56	5.99	6.65	20.95
E. (K) as Potassium sulphate .	7, 38, 43, 76, 88	64.31	6.78	28.90	5.99	6.14	19.86

NOTE:—

Ammonium sulphate to supply 40 lbs. of N per acre.

Super phosphate to supply 80 lbs. of P₂O₅ per acre.

Potassium sulphate to supply 50 lbs. of K₂O per acre.

(2) The yield data and recoveries of mineral nutrients by kharif 1946 crop, cowpea in the legume rotation following the phosphatic fertilised berseem were greater than those of cowpea crop following unmanured berseem indicating that the fertility level of phosphatic fertilised lysimeter was high. In the non-legume rotation the yield and recoveries of minerals by maruva crop following wheat receiving NP treatment were maximum as compared to the yields and recoveries by the maruva crop following wheat under other treatments. There was not much difference between yields of amounts of nutrients removed by the crop receiving O, N or P treatments.

(3) As judged by crop recoveries at the time of sowing wheat crop (rabi 1946-47) 35 lbs. of P₂O₅ out of 100 lbs. P₂O₅ added were removed by the previous crops in the legume rotation. 27 lbs. and 83 lbs. of nitrogen were removed from lysimeters receiving N and NP treatments where 80 lbs. of nitrogen per acre were applied in the non-legume rotation. In this rotation 6 lbs. and 26 lbs. of P₂O₅ were removed by the previous crops from the P and NP treated lysimeters. In view of the above position, the fertility levels of P treated lysimeter in legume rotation and NP treated lysimeter in non-legume rotation were lowered. However the yields of and recoveries of minerals by wheat

following cowpeas after P treated berseem were greater than those of wheat in the non-legumes series following maruva after NP treated wheat, showing the superiority of phosphatic manuring of legume in building up fertility in this season over the application of nitrogen and phosphatic fertilisers to the first cereal crop and maintaining a purely cereal rotation—wheat-maruva-wheat.

(iii) Micro-nutrient studies

(1) *The effect of micro-nutrient on the yields and quality of crops.*

(a) *Barley*.—The layout in pot-culture was replicated treatments of no manure, nitrogen N_1 at 50 lbs. per acre, N_2 at 100 lbs. per acre, P_2O_5 — P_1 at 30 lbs., P_2 at 60 lbs. and combinations of these each with and without the addition of 1 lb. of B, Mn, Cu and Zn. It was noted in Delhi soils that the effect of these minor elements on the yield, quality and the crop composition of barley was dependent largely upon the major manurial treatment. There was a definite increase in the yield of grain by the addition of higher doses of P due to the presence of micro-nutrient while the effect of higher level of N was to decrease it, leading in some cases to harmful effect. The quality as judged by the weight of 1,000 grain from different treatments show that grain obtained from no manure, N, N_2 and N_1+P_1 were higher in weight while in the case of N_1+P_2 , N_2+P_1 and N_2+P_2 treated pots it was lower. The % N in grain was found to have been increased only in no manure and N_2+P_2 and N_2 treatment, while in all the other cases there was a decrease. The uptake of P increased only in N_2+P_2 , N_2 and N_1+P_1 treatment. The malting quality as judged by Bishop's formula was higher in all the cases except no manure and N_2+P_2 treatment. The presence of micro-nutrient elements affected P/N ratio in plants.

(b) *Tobacco*.—The effect of nitrogenous manures in giving bad colour and thickening of leaves could be lessened by the application of B, Zn, Cu and Mn to Delhi soils. The effect was marked more in the Adcock variety than in the Harrison special variety.

(2) *The effect of trace-elements on the disease-resisting quality of tobacco.*

The effect of micro-nutrient elements on the resistance to the leaf curl disease was studied and found that by adjusting P/N ratio, the leaf curl diseases could be checked. Harrison special tobacco which withstood the infection of leaf curl disease had higher P/N ratio than the corresponding susceptible samples. Even after the onset of the disease, the further spread of the disease could be checked by raising the P/N ratio of the manures. The effect of additional nitrogenous manures increased the susceptibility to the disease but addition of micro-nutrients lowered it to a certain extent. Better results are, however, obtained by directly altering the P/N ratio by the addition of Phosphorus.

(3) *Wilt disease of Gram.*

During the investigation on gram wilt it was found that a number of plants were showing the bronzing symptoms. Older plants were the first to be attacked than the younger ones. The bronzing appeared first on the margins and then progressively spread over the whole leaf.

Mycological examination of the rootlets of the diseased plants did not show any parasite. Chemical aspect was therefore taken for investigations.

Samples of diseased and healthy plants were collected. Sampling was done twice one at the active vegetative period and the other during grain forming stage. The soil samples were also collected at the same time. The analysis was taken up.

(a) Evaluation of minor element determinations. (I. C. A. E.)

The study of minor element deficiencies in causing the disease like "Mottle-leaf", "die-back" and "Premature fruit shedding" in citrus plants and Malt-leaves has been undertaken.

The material for the investigation was obtained from Ujallpur and Kodur. Samples of Malt-leaves healthy and affected by "Mottle-leaf" were obtained from Ujallpur and samples of citrus plants affected by "mottle-leaf", "die-back" and "Premature fruit shedding" were obtained from Kodur.

The analysis of soils, growth habit and diseased plants is in progress.

Plant analysis.—Healthy and diseased leaves from Ujallpur showed no significant difference in the contents of SiO_2 , Fe_2O_3 , CaO and K, whereas the content of micronutrients like Mn and Zn were found to be more in the healthy samples than the diseased ones as shown below:—

Minor elements.	Healthy.	Diseased
Mn. Mg 100 gm.	8.2	5.8
Zn. Mg 100 gm.	18.05	5.2

Similarly the leaves affected by "Mottle-leaf", "die-back" and "Premature fruit shedding" also showed no significant difference in the content of SiO_2 , Fe_2O_3 , CaO and K between the healthy and diseased ones. However, the content of minor elements like B and Cu were found to be always higher in healthy plant than the diseased one as can be seen below:—

Micro-elements	Healthy leaf mg 100 gm.	Diseased leaf mg 100 gm.	Symptoms of the disease.
Boron	0.24	0.18	Die-back.
Manganese	5.3	1.1	Mottle-leaf.
Copper	4.1	2.4	Die-back.

Boron was found to be higher in healthy leaf than the one affected by die-back disease. Manganese was higher in the healthy leaf than the one affected by mottle-leaf or by die-back.

(iv) Soil Physics

1. Standardisation of conditions for the determinations of pF and permeability of soils of Dilly Farm are in progress. Four more determinations are also on hand in connection with permeability studies.

2. Studies of soil colour and coloured mulches.

The effect of surface colour of soil on temperature and plant growth was studied by putting coloured mulches on the soils. It was found that white mulch, for between 100 and 4000 hours for growth and colour temp. was the best as observed on the growth and yield. These results were confirmed by using culture-solution with the same nutrient solution but with different coloured outer surface. The relative value of colours, red, black, white, blue, green and yellow on the growth of plant depended on the effect on the diatrophic heat units and the thermal periodicity produced by each colour and on the changes in the evaporation of water, as a result of the temperature produced by the different colours.

(v) Physical Chemistry.

(1) Studies of colloidal constituents of soils collected from different horizons of a black cotton soil profile. (I. C. A. R. Scheme).

Material.—The material for this investigation is a soil profile of a black cotton soil obtained from feature. The soil samples were collected according to Harp's method.

H-clays were prepared from the seven soil samples of the profile. All the seven H-clays samples were subjected to fusion analysis and the amount of SiO_2 , Fe_2O_3 , MgO and K_2O determined. SiO_2 was found to vary from 55 to 63 per cent, while Fe_2O_3 varied between 31 and 46 per cent. While MgO varied between 2.5 and 4.5 per cent, and K_2O was about 0.3 to 0.4 per cent. The base exchange capacities of the first 5 H-clays, i.e., up to the depth of 12", were determined by potentiometric titration with $\text{Ba}(\text{OH})_2$; the b.e.c. varied within the range of 50 to 65 m.e. per 100 gm. of clay.

Saturation and desaturation experiments with the same 5 H-clays were conducted. The H-clay was repeatedly leached with neutral N. BaCl_2 and estimates of (a) the exchange acidity and (b) the amount of aluminium in the leachate were made. The process was continued till Al ion could not be detected in the leachate. The Ba clay was then reconverted to H-clay by leaching with dil. HCl and the H-clay was again submitted to similar treatment as before. It was found that, in all 5 cases the rate of $\text{H}^+\text{ex}/\text{Al}^{+++}$ increased with successive desaturation. The values of the ratio $\text{H}^+\text{ex}/\text{Al}^{+++}$ changed from 1.3 in the first desaturation to 11.4 in the third desaturation.

Humid acid soils were prepared from the first 5 clays of the black cotton soil, by the method of Stevens and Waksman. The base exchange capacities of the soils were determined by potentiometric titration with NaOH , $\text{Ba}(\text{OH})_2$, $\text{Ca}(\text{OH})_2$. It was found generally that the b.e.c. determined with different bases varied in the following order,

$\text{Ca}(\text{OH})_2/\text{Ba}(\text{OH})_2/\text{NaOH}$, e.g.; as instance $\text{Ca}(\text{OH})_2$, 502 me/100 gm.; $\text{Ba}(\text{OH})_2$, 455 me/100; NaOH 383 me/100 gm.

(vi) Soil Survey

I. A. R. I. Farm.—Out of the total area of about 500 acres so far nearly 30 acres have been surveyed. 26 profiles have been examined and about 80 soil samples collected for the analysis.

In the plot 11 the profiles did not vary essentially in the general feature. A light to yellowish brown colour was prominent in all the cases with a sandy loam to clay loam texture. The first horizon possessed generally cloddy structure and was compact and contained plant roots up to a depth not exceeding 10" from the surface. The lower horizon showed heavy soil with a darker colour than the top, while in one profile the third horizon was a mixture of coarse sand and gravel of different sizes. Salt efflorescences were visible in varying degrees.

In the plots 16 and 17 (Botany Division) the general features also did not vary very much from one another. A light brown sandy layer varying from 4" to 13" was found generally. But in three out of five profiles a compact zone, not exceeding 6" in depth, was noted. Texturally it was not heavy and appeared to have been formed as a result of mechanical compaction. This zone hardly contained any root. The sub-soil was sandy loam to loam and was characterised by the presence of fibrous deposits of salts. Lime concentrations of small size were present in varying quantities at a depth ranging between 4" and 27".

In plots 14, 15, 16 and 17 of main block the difference in profile features was the presence or absence of carbonates. The texture in some cases appeared to be sandy loam while in others it has clay loam. In a few cases salt efflorescences were noted.

Karnal Sub-station.—A survey of nearly 116 acres at Karnal was finished and 14 profiles were examined and 22 soil samples have been collected.

In the plot V the soils were found to be lighter in colour and texture, having a very compact and hard layer just below the cultivated layer. The presence of black concretions was prominent and mottling was noticed at lower depths, while in the profiles from plot VI (known as rice field) the upper horizon was dry and very compact with reddish brown mottling. The next lower horizons were generally moist with darker colour and fairly developed clay, cloddy or prismatic structure. The bottom layer showed yellow to brown mottling and contained black concretions of varying sizes. In a few cases the whole profile showed effervescences with dilute HCl, while in others there was none. In the case of a profile taken in an uncultivated land near rice field in the same plot, viz., plot VI where grass was the chief vegetation, the soil was lighter brown with a definite zone of salt accumulation at a lower depth (6"-13").

(2) Saline and alkaline patches at Karnal.

The profiles as reported in the previous report (annual report, 1946) was analysed for their mechanical composition and a few chemical constituents. The mechanical composition showed that the surface horizon to a depth of 0-7" and in one case up to 21" was of sandy loam texture, with clay content between 6 and 18 per cent., while immediately below it was sandy clay loam horizon with a definite accumulation of clay. The clay content in this horizon was between 19 and 28 per cent. Carbonates were between 0.1 and 2 per cent, but in a few cases a layer of kankar was met with a depth of 48" and below. The reaction of the soils in profile I and III was very strongly alkaline where pH was between 9.0 to 10.4, while profile II and III was neutral to mildly alkaline as the pH varied from 6.7 to 7.9. The total salts generally varied from 1.46 to 7.1 per cent, and predominant among them was the sodium sulphate. The exchange capacity of the first horizon was from 7 to 12 m.e. 100 gm. soil, where as in the lower horizon it varied between 12 and 17 m.e. Sodium saturation in a few cases was above 80 per cent, while in others it was between 10 and 40 per cent. This showed the extent of alkalinity in these soils.

Rapid Reconnaissance Survey.

Ajmer.—A rapid reconnaissance survey of about 200 acres land, lying about 14 miles south-west of Ajmer town, was undertaken at the request of the Agricultural Officer, Ajmer-Merwara. The area is proposed to be irrigated by the construction of a reservoir in Gauri-kund Hills near Saradhana.

Three profiles have been examined and 11 soil samples collected. The soils were of sandy texture with clay content below 10 per cent. They were low in soluble salts. The reaction of the soils showed that these were mildly alkaline to strongly alkaline as pH was between 7.9 to 8.2. The phosphate, nitrogen and organic matter contents of these soils were low. The SiO_2 , R_2O_3 ratio of clay was 2.5.

The soils from the analysis showed that these soils might be used under irrigation with suitable amendments.

Lucknow.—A rapid reconnaissance survey of nearly 500 acres of the Bhadrak farm at Lucknow was undertaken at the request of Vice-Chairman (I. C. A. R.) to find out the suitability or otherwise for the cultivation of sugarcane crop. 11 profiles were examined and 20 soil samples were collected for analysis.

The texture of top horizon was sandy loam to loam and internal drainage condition of the soil was satisfactory. Its content of soluble salt was below 0.2 per cent, and is generally of the order of 0.06 per cent, and was therefore fairly low and was not likely to constitute any danger as such, especially if proper drainage could be provided.

The lime content was about 0.5 per cent. Base exchange capacity of soils was of the order of 11 m.e./100 gm. soil. P_2O_5 was low, the land as judged from the analysis seems to be suitable for sugarcane cultivation if it is subjected to suitable irrigation drainage, liming and application of P_2O_5 .

A map of the area surveyed at Lucknow with the present land use was prepared.

Jubbulpore.—A rapid reconnaissance survey of nearly 3,000 acres at Jubbulpore near the Khamaria Ordnance Factory was undertaken at the request of Animal Husbandry Commissioner (I. C. A. R.) for its suitability or otherwise for establishing a Central Cattle Breeding Farm. In all 11 profiles were examined morphologically and 35 soil samples collected.

A base map of the area surveyed at Jubbulpore was prepared on a scale of 4" to 1 mile and field notes were recorded and a complete map of physical features and land use was prepared. Further work is in progress.

Rann of Cutch.—At the request of North Western Railway Authorities, a very rapid reconnaissance soil survey of Rann of Cutch has been carried out with the object of assessing the suitability of the area for agricultural purposes.

The area surveyed at selective sections and 8 profiles were examined and 62 soil samples collected for analyses. Surface deposits of salt occur at Bela and Kavda and in the other areas salt layers occur in the profile at varying depths. The whole area is almost barren.

A map of Rann of Cutch area with its present condition was prepared.

Further work is in progress.

(vii). Plant Chemistry

Tobacco.—Work on tobacco was undertaken in collaboration with the Divisions of Botany and Entomology with a view to finding out nicotine rich varieties in relation to their insecticidal varieties. During the course of this work on varieties from the I. A. R. I. it was noticed that the samples did not contain high percentages of nicotine as it is found in certain varieties of tobacco grown in Kenya, Germany or Russia and it was considered necessary to find out whether tobacco from any part of India is rich in nicotine content. Accordingly all the Directors of the Provinces as well as the five Excise Collectorates into which India is divided were requested to send as many samples of tobacco as possible. More than three hundred samples have been received which are being analysed.

Pyrethrum.—On account of the growing importance of the drug as an insecticide the work was started in all-India basis in order to ascertain pyrethrum I and II content in the petroleum ether extract of the flower. Samples of pyrethrum flowers were received from almost all pyrethrum growing centres and the results indicated that the content varied from 0.67 to 1.58 per cent.

Sword beans.—A wild variety of sword beans was obtained from Baroda and the work was undertaken to ascertain its suitability as fodder to animals. Flower, pods, seeds, leaves and other parts were fed separately to albino rats but none showed any poisonous symptoms. On the other hand all the parts showed absence of oxalic acid, nitrite and arsenic. From the results of the analysis of the material it appears that the sword beans can be used as fodder to animals.

(viii). Microbiology

Biological reversion of phosphate.

Experiments were conducted to examine phosphate absorbing power of nitrogen fixing organisms.

These results showed that the organisms reached the stage of active phase after a period of 5 days when the absorption of phosphate and fixation of nitrogen were at a fairly rapid rate.

Further experiments conducted with a pure culture of *Azotobacter* isolated from Delhi showed that such a culture absorbed less phosphate and fixed less nitrogen than mixed flora of the soil did.

Nitrogen transformations.—Work for examining the nitrifiability of nitrogen of different manures at different levels of moisture and at different incubation temperatures in some representative soils was taken up. During the year under report experiments were conducted with Delhi soil using rape seed and castor seed cakes. Incubation temperatures were 37° C., 30° C., and 20° C. while the levels of moisture were $\frac{1}{4}$, $\frac{1}{3}$, and $\frac{1}{2}$ saturation.

Conclusions drawn from observations extended over a period of 8 weeks are as follows:—

Half saturation proved better than one-third and the latter was found superior to one-fourth saturation at all temperatures. So far as the influence of temperature is concerned within the same range of saturation the results are erratic.

Study of the root nodule organisms.

A number of strains of urid and soyabean organisms were isolated and their efficiency was tested by inoculation and cross inoculation studies. Of the three soyabean strains tested for nitrogen fixation in symbiosis with plants S.B. 7 and S.B. 9 proved efficient. They increased the nitrogen content of the plants by 19.26 mgm. and 10.74 mgm. against 3.6 gms. fixed in the control plants.

Under field condition at Pusa the effect of inoculation was not seen.

Inoculation experiments with cowpeas.

Field experiments conducted at Delhi with cowpeas using two strains K. 700 and K. 397 did not increase the yield of cowpea over the control.

Gram strains.—Efforts made to isolate efficient strains of gram organisms did not meet with success as there was no satisfactory growth of organisms in the plates.

Influence of root nodule extract on the fixation of nitrogen in Ashby's solution by *Azotobacter* and root nodule organisms of soyabean and gram was examined.

Fuel gas.—With a view to increase production of fuel gas and to get better quality of manure the system of loading the Divisional pilot tank was modified. Instead of loading it with 10 lbs. of fresh dung every day it was decided to loam it with 150 lbs. every fortnight. This gave higher production of gas as could be seen from the following comparative figures:—

Year.	Gas produced during the month of June out of 300 lbs. of dung added.
1943	206 cft.
1944	208 cft.
1945	213 cft.
1946	—
1947	263 cft.

As regards quality of manure its value will be tested with wheat in the coming season.

Butanol.—For increasing the efficiency of the butanol organisms with phosphate, experiments were conducted in which varying amounts of K_2HPO_4 , 0.1 per cent., 0.25 per cent. and 0.5 per cent. were added to maize, molasses and oil cake mash. In maize mash the addition of phosphate had no effect on the yield of butanol but in molasses-oil-cake mash the production of butanol increased with the increasing doses of P_2O_5 .

Efficiency of two American Cultures of butanol organisms was tested with that of the local organism. The latter was found to be as efficient as the formers.

Gram wilt.—As the disease appeared both healthy and diseased plants were examined for the formation of nodules. It was found that the diseased plants had poor nodulation and even those that were formed were unhealthy. The organisms were not the cause of the disease but the poor development of the nodules was the result of the disease in the plant. It was also observed that the soil surrounding the diseased plants contained more nitrite. When the gram plants grown in pots were treated with equal and double the quantity of nitrite found in soil around the diseased plants, symptoms of disease appeared and where double dose of nitrite was used the plants died.

Ammonium nitrate.—Residual effect of ammonium nitrate was examined by taking a crop of maize from the experimental plots in the Division of Chemistry. Yield of the plots under each treatment showed no residual effect.

Wheat manured with different manures in an experiment to be compared with ammonium nitrate were analysed for Nitrogen, P_2O_5 and Ash.

These results showed that the wheat manured with ammonium nitrate contained more N, more P_2O_5 and more Ash than the wheat manured with ammonium sulphate.

Nitrogenous manures increased the nitrogen percentage along with yield but reverse as the case with phosphatic manures. Wheat of the control plots contained the highest amount of P_2O_5 and ash.

NITROGEN FIXATION SCHEME.

A new scheme financed by I. C. A. R. for Nitrogen Fixation studies come into operation from June, 1947.

(ix) Biochemistry

Mineral metabolism in Sahiwal cows.

Period.	The experiment was conducted at I.A.R.I. Dairy Farm. High milking cows (second calvers) two in the second week and two in the third week of lactation were selected for the experiment. The experiment was planned on Latin square basis and unmanured Green Berseem, manured Green Berseem, Green Lucerne and Jowar silage supplemented by Lucerne hay were fed. A complete account of the intake and output was kept and the following minerals, Calcium, phosphorus, sodium, magnesium, potassium and chlorine were being analysed. The analytical work is in progress.			
1	2	3	4	
A	B	C	D	
B	C	D	A	
C	D	A	B	
D	A	B	C	

COMPOST SCHEME.

Destruction of viability of weed seeds.

Two series of experiments were conducted to examine the loss of viability of weed seeds during the process of composting.

Visual observations indicated the onset of germination of some weeds when decomposition had proceeded for 2-3 months' plumules were seen elongating abnormally and ultimately dyeing inside the mass. Even hard-coated seeds were seen being decomposed.

Actual germination tests of the samples after varying periods of decomposition have indicated a loss of viability of about 40 per cent. at the end of the first month rising to over 92 per cent. by the end of the sixth month. The only weed that was not destroyed after the 5th month of decomposition was *Xanthium stammanium*. All other weeds were completely destroyed at the end of 5 months decomposition.

TOBACCO SCHEME.

Chemical changes during flue-curing of tobacco which was studied. It was found that while there were no marked differences between grade to grade, the leaves could be divided into two broad categories. Grade 1 to 4 were characterised by high ash content, high soluble solids, high reducing and total sugars, and low total nitrogen, while the reverse was true of grades 5, light green and dark green. Thus it appears that leaf grades cannot be distinguished on the basis of chemical composition alone, specially when the position of the leaf on the plant is not known.

A study of the composition of leaf and soil samples collected from the good and bad tobacco-growing areas of Guntur District was also taken up. It may be seen that good leaf is characterised by high sugar content and low nitrogen, while the reverse is true of poor leaf.

Composition of leaf and soil samples collected from good and poor tobacco-growing areas of Guntur district.

Name of the place from which samples were collected.	Kesavarapadu.	Ponnekal.	Pasumaadu. (good field.)	Pasumaadu. (Poor field.)	Narukulla-padu.	Appalapadu.	Audipadu.
Quality of leaf. Picking of the leaf.	Good 1st	Poor 1st	Good 5th	Poor 5th	Good 2nd	Good 8th	Poor 3rd
<i>Leaf analyses.</i>							
Reducing sugars . . . per cent.	13.62	5.78	11.28	9.75	14.77	12.79	14.51
Total sugars "	15.14	6.81	13.21	9.75	16.84	15.79	16.15
Total N "	1.67	3.33	1.98	2.38	1.64	1.89	1.91
K ₂ O "	1.50	2.62	2.01	1.87	2.68	1.56	1.97
P ₂ O ₅ "	0.40	0.41	0.311	0.46	0.31	0.608	0.34
Ash "	13.79	16.75	18.34	15.93	16.58	13.32	13.35
<i>Surface soil analysis. (0-6")</i>							
Clay "	59.92	57.18	57.84	60.01	70.96	59.41	71.01
Silt "	13.76	18.86	24.24	20.02	19.60	24.81	19.32
Sand "	26.32	23.96	17.92	19.97	9.44	15.78	9.70
Loss on ignition . . . "	3.66	5.04	4.54	4.51	5.55	3.89	5.26

Composition of leaf and soil samples collected from good and poor tobacco-growing areas of Guntur district—contd.

Name of the place from which samples were collected.	Kesavarapadu.	Ponnekal.	Pasumaadu. (good field.)	Pasumaadu. (Poor field.)	Narakullapadu.	Appalapadu.	Audipadu.
Quality of leaf. Picking of the leaf.	Good 1st	Poor 1st	Good 5th	Poor 5th	Good 2nd	Good 8th	Poor 3rd
Organic Nitrogen . . . per cent.	0.023	0.033	0.029	0.030	0.033	0.039	0.033
Hot soluble CaO . . . „	1.81	2.92	3.24	2.80	2.75	3.63	2.63
„ MgO . . . „	1.77	2.37	2.05	2.40	2.09	2.39	2.10
„ K ₂ O . . . „	1.79	0.64	0.84	0.99	0.79	1.01	1.07
„ P ₂ O ₅ . . . „	0.035	0.049	0.063	0.070	0.072	0.125	0.068
Citric Acid soluble P ₂ O ₅ . . . „	0.005	0.019	0.022	0.023	0.018	0.031	0.013
„ — pH . . . „	7.9	7.8	8.0	7.7	7.8	7.770	7.8
Citric acid sol. K ₂ O . . . „	0.014	0.023	0.007	0.026	0.024	0.025	0.025

Subsoil analysis. (6-18")

Citric acid soluble P ₂ O ₅ . . . „	0.005	0.011	0.019	0.017	0.015	0.024	0.013
„ K ₂ O . . . „	0.015	0.018	0.016	0.028	0.027	0.022	0.017
„ pH . . . „	7.8	8.1	7.7	7.8	7.7	7.8	8.1

II. ADVISORY

447 samples of the following descriptions were analysed and reported during the course of advisory work to various institutions in addition to analytical work undertaken in connection with research problems of the division.

Manures	22
Fertilisers	6
Feeding stuffs	83
Soil	69
Water	15 + 28
Plant	191
Alcohol	1
Opium merc	3
Coal clinker	1
Fruits	28

419 + 28 = 447

A few routine samples of interest may be mentioned. The analysis of waters from the 14 Institute wells was continued during the year to study the fluctuation in their salt concentration. The samples were once collected in October, 1946 and again in June, 1947. The analysis of October samples is reported here. The level of water in the wells has usually risen from year to year since July, 1942. The rise in various wells in the period from 1938 to 1946 varied from 7 to 13 feet. The main factors influencing the water level of wells were irrigation and rainfall. When the composition of waters of different wells for October, 1946 was compared with that for March, 1946, it was found that there was a rise of total salt concentration in four wells and fall in 9 wells, whereas in the remaining one there was not much variation. Other constituents like bicarbonates, chlorides and sulphates underwent corresponding variations.

A sample of well-water collected from the compound of the T. B. Hospital, Kingsway, Delhi, had high soluble salt content and should be used with caution for irrigating grass lawns, shrubs, etc., provided the soil was sandy or porous enough to drain away the salts to drainage channels and prevent their accumulation at the surface layers of the soil.

A sample of maize cake prepared from maize and oil cake and sent by the Division of Agriculture had 3.73 per cent. of nitrogen and 42 per cent. of carbonates. It would serve as a good feeding stuff.

A sample of Kudada phosphate from the above source had about 25 per cent. total P_2O_5 and 1.21 per cent. of P_2O_5 was soluble in 2 per cent. citric acid solution.

Six samples of healthy and termite-attacked wheat plants from the Division of Entomology were analysed for N, P_2O_5 and total sugars. Sugars were found more in the termite-attacked plants than in healthy ones. No significant differences were noticed with regard to the other constituents.

A blood manure from the Agricultural Officer, Ajmer-Merwara was found to contain about 5 per cent. N, 0.13 per cent. P_2O_5 and 0.48 per cent. K_2O .

A factory effluent from Messrs. Straw Products Ltd., Bhopal, was yellowish in colour due to dissolved organic matter which imparted smell to the effluent from fermentation. On further standing and filtration the effluent deepened in colour and deposited solid matter, finally turning lighter in colour. The total soluble salts were within limits and no harmful effects were expected on standing crops with its irrigation. The crops that were usually grown in the locality, might be tried with this effluent.

A sample of atom manure or *Uttam khad* from the Hindustan Chemistry Products, Hyderabad, was rather poor in all the major food elements for crops, though somewhat rich in organic matter being prepared from herbs, as stated by the manufacturers. Its analysis did not justify the high claims attributed to the manure, namely, 2 to 3 lb. of it would suffice for paddy crops.

A sample of defatted groundnut seeds from Mr. B. V. Vyas, Bhavnagar, contained about 11 per cent. of oil which is the average oil content of ordinary groundnut oil-cakes available in Indian markets. The claim of the sample having a much lower oil content was not therefore substantiated.

In connection with an enquiry from the Public Health Commissioner with the Government of India a detailed note on farinaceous materials in curry powder was prepared suggesting that the use of gram flour as an adulterant up to 10 per cent. should be permissible.

III. PROGRAMME OF WORK (1947-48)

I. Agricultural Chemistry (Manurial experiments)

1. Following collaborative field experiments on manurial trials with the Division of Agronomy to obtain confirmatory data regarding beneficial residual effects of phosphate manuring of legumes on the subsequent yield of wheat:—

- (i) to study to what level berseem treated with phosphates and followed by guar for 3 years builds up soil fertility.
- (ii) to study the effect of heavy doses of complete fertilizers (N, P and K) without legumes in building up soil fertility for comparison with (i) above.
- (iii) to compare the effect of introducing a legume like peas in rotation with wheat and maize with the results of (ii) above.
- (iv) to study the possibility of building up soil fertility by means of organic nitrogen in the form of oilcakes and green manures and to study their rate of decomposition under field conditions.

2. Water analyses including periodical examination of well waters in the Indian Agricultural Research Institute.

3. Analyses of manures, fertilizers, feeding stuffs, etc.

II. Soil Chemistry

4. Methods of soil analysis.
5. Analysis of soil samples.

III. Soil Fertility

6. Study of the mineral deficiencies (major elements) using indicator plants and comparison with other methods.

7. Plot experiments—the effect of phosphatic fertilizers on soil fertility.

8. (a) Phosphorus fixation in relation to soil fertility (estimation of total and available phosphates in the permanent manurial plots and berseem experiment plots in Delhi).

(b) To study the rate curves of phosphate solubility of different typical soils with various solvents.

9. Effect of N/P ratio on the growth and quality of crops with special reference to leaf curl disease of tobacco.

10. Studies on soil colour in relation to plant growth.

11. Studies on the nutritional level of plants grown in manurial plots by tissue analysis.

IV. Micronutrient elements

12. Comparison of the microchemical and spectrochemical methods of analysis.

13. Diagnosis of micronutrient deficiencies using indicator plants and injection methods.

14. Study of minor element deficiency diseases with reference to citrus (Indian Council of Agricultural Research Scheme).

V. Soil Physics

15. Studies on porespace, pF, water-holding capacity and permeability of typical soils.

VI. Physical Chemistry

16. Phosphate fixation by soils.
17. Studies on the chemical, electrochemical and viscous properties of colloidal constituents of soils obtained from different horizons of black cotton soil profile (Indian Council of Agricultural Research Scheme).

VII. Soil Survey

18. Survey of the Farm areas under Indian Agricultural Research Institute at Delhi, Pusa and Karnal and other selected places.

VIII. Plant Chemistry including soil organic matter

19. Work on tobacco with a view to finding out nicotine rich varieties of *N. rustica*.
20. Survey of pyrethrum from different parts of India for determining pyrethrins.
21. Survey of Derris and rotenone containing plants in India.
22. Studies on the organic matter of soil organic phosphates.

IX. Microbiology

23. Reversion of phosphoric acid through soil micro-organisms.
24. Influence of one crop upon another with special reference to the part played by root secretions and micro-organisms.
25. Nitrogen transformation in soil.
26. Influence of different types of phosphatic fertilizers on the formation of nodules and on nitrogen fixation by different legumes.
27. Study of efficient strains of root nodule organism.
28. Study of gram wilt disease in collaboration with different sections of this division and divisions of Mycology, Botany and Agronomy.
29. Study of wild leguminous plants and of pulses.

X. Biochemistry

30. Nutritional quality of crop as influenced by manuring. *Compost Scheme.* (I. C. A. R.)
31. Control on fly-emergence from compost trenches.
32. Destruction of viability of weed seeds during composting.

REPORT OF THE DIVISION OF ENTOMOLOGY (FOR THE YEAR ENDING JUNE, 1947.)

I. REPORT ON INVESTIGATIONS

1. *Discovery and control of insect vectors of virus diseases.*—(a) *Host-plants.*—The following were observed to be important host-plants of the white-fly, *Bemisia tabaci*, the vector of tobacco leaf-curl disease:—*Launea asplenifolia*, *Solanum nigrum*, *Althaea rosea* and *Lagenaria vulgaris*.

Transmission experiments repeated during the year under review confirmed that the leaf-curl disease could be transmitted from tobacco to papaya and from papaya back to tobacco by means of the same white-fly species. Unlike in the previous year where the incubation period was about 10 months, in the former case it was 2-4 weeks and 2-3 weeks in the latter.

In a co-operative experiment carried out with the Head of Agricultural Division on the effect of various manurial treatments on tobacco plants in pots and exposed to infection of leaf-curl disease, the following conclusions were drawn:—When the P/N ratio in the Delhi soil was increased by the addition of manures, the resistance of the plants to the leaf-curl disease increased. When, however, this ratio was decreased by the application of nitrogenous manures, the susceptibility to the disease increased. The bad effects of N could be mitigated by the application of minor elements like manganese, zinc, boron, etc., but definitely better results could be obtained by the use of superphosphate instead of minor elements.

(b) *Survey of sucking types of insects.*—The more important sucking insects observed on potato crop were *Empoasca kerri*, *Creontiades pallidifer*, *Aphis gossypii*, *Myzus persicae*, *Bemisia tabaci* and *Halticus minutus*.

2. *Insect Population Studies.*—The following main items of research were continued, viz., (A) Development of standardization of the technique of the population study, and (B) Collection of biotic and climatic data for the study of population fluctuation of the spotted bollworms of cotton.

As regards the collection of the data for the main long range experiment the following three items of routine observations had been continued: (a) Field census, (b) Field rearing, (c) Meteorological observations.

The population fluctuation of the spotted bollworms and pink bollworms along with their parasites had been worked out per acre.

Along with field rearing to supplement the field census, a new item of rearing the moths of *E. fabia* in order to determine the effect of food and climate on their longevity and fecundity was introduced. The adult moths were fed on the following feeds: (i) no food, (ii) water only, (iii) sugar, (iv) honey, (v) gur, (vi) cotton bolls and juice of bolls, (vii) date juice, (viii) molasses.

The data obtained are being analysed. From a preliminary analysis of the data the following tentative conclusion has been drawn. Sucrose solution prolonged longevity to the maximum and also increased fecundity.

Effect of different foods on larval periods.—The larvae were reared on holly-hock, *Abutilon*, bhindi and cotton. No appreciable difference was noticed in the larval periods under the same conditions of the field. There was again no difference in pupal periods of these larvae. These experiments will be further continued.

Field rearing to find out the developmental periods and rate of development of various stages of *E. fabia* was also continued. A mass of useful data on the duration of all the stages of *E. fabia* covering all the weeks of the year have been accumulated for analysis.

During the previous years attempts had been made to interpret the population fluctuation of *E. fabia* and *E. insulana* together. This year, however, each species was studied separately under different ecological conditions. The object of these studies are to find out the causes of their relative abundance in the different parts of the world with particular reference to India.

A study of the population of the parasite fluctuation (*Rhogas* sp.) during the last five years in relation to its host (cotton bollworms) was also undertaken. The following tentative conclusions were drawn: (i) The population fluctuation of the parasite is generally proportional to that of the host; (ii) Like the percentage incidence the percentage of parasitization gives no correct idea about the intensity of the population and its effectiveness; (iii) The effectiveness of the parasite does not mainly depend upon its number. A relatively smaller population of the parasite may prove more effective under favourable conditions; (iv) Though the parasites depend for their existence on the presence of the host, yet their rate of development and multiplication are greatly influenced by eco-climates.

Biograph and Biometer.—This useful instrument designed in this Division and described in the previous years' reports has been further improved and perfected. The pupal and egg-biometer were put to practical test. The duration periods of pupae and eggs of *E. fabia* observed throughout the year were compared with those of the calculated periods. They were found to agree appreciably. The larval-biometer was also constructed. Biothermic values for all the 3 stages had been computed for the year and it is hoped with further improvement and perfection these biometers can safely be used instead of elaborate and often times difficult field rearing.

3. *Pests of Stored Food-stuffs.*—I. *Pests of jowar.*—The following investigations were carried out:—

(i) *Varietal resistance and susceptibility of jowar.*—About 24 varieties of jowar from different provinces were experimented upon to study the comparative merit of resistance or susceptibility to the important pests of jowar, viz., *Rhizopertha dominica*, *Corcyra cephalonica*, *Sitophilus oryzae* and *Latheticus oryzae*.

J. S. 20 from the Punjab, M.47-3 and most of the Coimbatore varieties were susceptible to *C. cephalonica* while Imperial Saoner and EB from Central Provinces, JS 100 and JS 59 from the Punjab, CO₄ and CO₆ from Coimbatore and AKP₃, AKP₁ from Anakapalle were somewhat susceptible to this species in different degrees in the order of their mention.

J. S. 20 (unhusked variety) was also susceptible to *R. dominica* while JS 21, Imperial Saoner; CO₄, CO₅, CO₆ from Coimbatore; 123A, M.47-3 from Central Provinces were more or less resistant. AKP₃, CO₄, JS 263 and EB, were found to be susceptible to *L. oryzae* and 123A, M.47-3, JS 20 are resistant to it. As the last-named species was a minor pest of jowar it was not tried with all the jowar varieties. CO₂, CO₃, N₁, N₂, AKP, AKP₃ and EB varieties were more or less resistant to *S. oryzae* while EB₃, 123 A Coq., M.47-3, JS 21 were susceptible to it. The other varieties were somewhat intermediate in position.

Not a single variety was found entirely immune to any of the abovementioned pests. Only JS 20 from the Punjab was found almost resistant to all the pests except *R. dominica*. This is probably due to its being an unhusked variety. The resistance or susceptibility of the various varieties depends upon factors like hardness or softness of the grain, percentage of moisture content and other factors which are still under investigation.

It may be mentioned here that there was very little consistency in the replication with the same pest and the same variety.

(ii) The effect of air-tight versus well-ventilated conditions on the multiplication of pests in the store was still under investigation.

(iii) *Study of fumigants*.—A few fumigants, viz., methyl bromide and ethylene dioxide were tried in air-tight cylindrical iron bins to ascertain the lethal doses against storage pests.

(a) *Methyl bromide*.—With a dose of $1\frac{1}{2}$ lb. per 1,000 cu.ft. of space and 2 hours exposure there was a cent. per cent. mortality in the case of *S. oryzae* and *C. cephalonica* (larvae) at a maximum room temperature of 92° F. and minimum 90° F. With a dose of 1 lb. per 100 cu.ft. and exposure for 2 hours, there was cent. per cent. mortality in all the above pests; with 1 lb. per 1,000 cu.ft. and 1 hour exposure *Tribolium* sp. was not killed while cent. per cent. mortality of *S. oryzae* was obtained after 20 hours, of the fumigation.

(b) *Ethylene dichloride*.—Preliminary trials with 6 lbs./1,000 cu.ft. dose and 24 hours exposure at a maximum temperature of 98° F. and a minimum temperature of 93° F. showed cent. per cent. kill of *C. cephalonica* (larvae), *Tribolium* sp. and *S. oryzae* in the empty bins but in bins filled with grains there was no mortality in the middle and at the bottom, thus showing that ethylene dichloride has comparatively less penetrating effect than methyl bromide.

II. *Pests of dry fruits*.—The following were the observations recorded:—

(a) *Injury to apples*.—Preliminary experiments were carried out to study the effect of methyl bromide fumigation on apples as regards visible injury. Different dosages, i.e., 1, 2, 3 and 4 lbs./1,000 cu.ft. at different exposures of 1, 2, 3 and 4 hours were tried at atmospheric temperature and humidity varying from 80-100 per cent. These experiments have shown tentatively that the dosages 1 and 2 lbs./1,000 cu. ft. can be used with exposures less than 2 hours for apples coming from Baluchistan. Higher dosages like 3 and 4 lbs./1,100 cu. ft. should have exposures below 1 hour, otherwise the fumigant is likely to injure the apples causing rotting within a short time.

(b) *Lethal dosage of hibernating codling moth larvae*.—Larvae in and outside the cocoons were fumigated with methyl bromide using different doses and exposures. It was found that a dosage of 2 lbs./1,000 cu. ft. for 2 hours at $60-65^{\circ}$ F. gave a complete kill.

(c) *Dried fruit pests*.—A number of experiments were conducted with *Oryzaephilus surinamensis* and *Tribolium castaneum* (larvae and adults) using different dosages and exposures. They have shown that a dosage of 1 lb./1,000 cu.ft. for $1\frac{1}{2}$ hour is sufficient to obtain complete kill of *O. surinamensis* and 1 lb./1,000 cu.ft. for 2 hours for *T. castaneum* in the case of larvae and adults.

III. *Pests of stored pulses*.—(i) *Extent of infestation at harvest time*.—The extent of infestation at harvest time was estimated by examining random samples from mature crops in the fields as also from harvested crops, thrashed and unthrashed at I. A. R. I., New Delhi and also at various places in India. Amongst the pulses, cowpea, pea, arhar and mung were observed to be very susceptible to *Bruchus* attack. The percentage of damage to grains in the store was as follows:—gram 5 to 9 per cent., arhar 8 to 20 per cent. and cowpea 6 to 31 per cent. The percentage of attack in pulses standing in the fields was as follows:—gram 4 per cent. and arhar 3 per cent.

In other standing pulses there was no infestation except in peas where on one occasion a solitary *B. vectabitiolis* was found.

(ii) *Fumigation*.—Methyl bromide, carbon bisulphide and ethylene dichloride were tried in air-tight iron bins to find out the lethal doses against jowar pests.

(a) *Carbon bisulphide*.—A cent. per cent. mortality of adults and grubs of bruchids was obtained with 2 lbs., 4 lbs. and 6 lbs. per 1,000 cu.ft. of space and 24 hours exposure. But the eggs were not affected to any appreciable extent as 60-90 per cent. hatched out a few days after their exposure. This was specially noted in those cases where the exposure and doses were much less, $\frac{1}{2}$ -1 lb.

(b) *Methyl bromide*.—Fumigation with this fumigant was carried out in an iron air-tight drum in which the requisite doses of the fumigant were let in by providing special fittings. Doses ranging from 1- $\frac{1}{2}$ lb./1,000 cu.ft. of space with 1 to hours exposure were tried. It was found that at 93° F. (maximum) and 92° F. (minimum) cent. per cent. mortality of all the stages of bruchids was obtained. Methyl bromide was found better than CS₂ in that it kills the eggs also, the percentage mortality being 80-100 per cent.

(c) *Ethylene dichloride*.—Preliminary trials were carried out with this fumigant at 6 lbs./1,000 cu.ft. of space and 24 hours exposure in air-tight iron cylindrical bins. In empty bins there was cent. per cent. mortality of adult bruchids against zero per cent. mortality in the bins full of grains. These observations show that the fumigant has very little penetrating power. The viability of all the above treated grains was not affected.

(iii) Experiments were conducted with different pulses (broken, washed, whole and without skin) to study the breeding of bruchids in them. Whole mung, urid and masur showed the maximum amount of breeding of bruchids specially in the air-tight receptacles. Broken mung (with skin) also showed a slight breeding. But in other broken pulses there was no breeding at all. These differences in breeding habits are due to the fact that milling reduces the moisture content of the grains and the broken halves of the pulses do not contain enough space for the grubs to lie and feed therein.

(iv) *Use of preservatives*.—Various preservatives, viz., D.D.T., 666, inert dusts, vegetable oils and other chemicals were tried to study which of them prevents or stops the breeding of bruchids in the pulses. The doses tried were as follows:—

Mercury	1 lb. per maund of grain.
D.D.T. and 666	1:100,000.
Copper carbonate	1:2,000.

In the treated pulses the breeding of bruchids was very low and the loss of weight was also much less especially in the vegetable oils. D.D.T. and 666, however, showed the least damage.

The pulses treated with inert dusts (coal ash clinker, rock phosphate and chalk) 1:100 showed maximum damage and breeding of bruchids.

(v) The effect of air-tight versus well ventilated conditions of storage on the multiplication of bruchids are under investigation.

(vi) *Disinfection of grains (pulses) before storage*.—Experiments performed with dry heat and hot water treatment showed that both dry heat and hot water at 55° C.-60° C. could kill all pests with an exposure of 30 seconds to 1 $\frac{1}{2}$ minutes. Dry heat gave better and quicker results.

4. *Biological Control of pests of Sugarcane*.—*Trichogramma* colonisation field experiments at Cuttack (Orissa).—To start with the egg parasitisation of the stem-borer, *Argyria sticticraspis* in the experimental blocks was 5.9 per cent. and in the control blocks

15.15 per cent. In June, 1946, the egg parasitisation in the six liberation blocks was 89.12 per cent., in the twelve liberation blocks 83.48 per cent. and in the control blocks *nil*. Maximum parasitisation of 100 per cent. was observed in some of the experimental blocks in some of the series of observations from June to October while the parasitisation in the control blocks was mostly *nil* during the corresponding period. In October very few egg masses were observed in the experimental blocks and they were all cent. per cent. parasitised, while in the control blocks the parasitisation was only 25.12 per cent. during the same month.

Thus a steady increase of parasitisation from 5.9 per cent. to 100 per cent. has been observed in the experimental blocks. The figures show that the stem-borer can be fairly controlled by timely liberations of the parasite.

In June, 1946, *Argyria sticticraspis* damaged 6.9 per cent. of the shoots in the six liberation blocks, 5.02 per cent. in the twelve liberation blocks and 26.60 per cent. of the shoots in the control blocks. The peak was, however, reached in May when a maximum damage of 12.0 per cent. and 15.4 per cent. was observed in the six- and twelve-liberation blocks against 46.6 per cent. in the control. At the time of harvest the corresponding figures were 11.5 per cent., 11.25 per cent. and 26.05 per cent. respectively. The larval and pupal populations, per acre, at the time of harvest was 440, 300 and 650 in the six-liberation, twelve-liberation and control blocks respectively. The average yield of cane at the time of harvest in the six liberation blocks was 618.6 maunds per acre, in the twelve-liberation blocks 685.6 maunds per acre and in the control 522.9 maunds per acre.

1947-48 experiments.—Eight blocks of five acres each were laid out at Banki in December and these were planted with CO. 421. The parasitisation before commencement of parasite liberations was 7.2 per cent. in the experimental blocks against 7.4 per cent. in the control. *Argyria sticticraspis* damaged 2.2 per cent. of the shoots in the experimental blocks against 2.65 per cent. in the control. Further parasite liberations, stem-borer egg parasitisation and borer population studies are in progress.

The *Pyrilla* parasite conservation experiments were repeated at Karnal in two different sets of six blocks of $\frac{1}{2}$ acre and one acre each respectively. Up to July, 1946, the *Pyrilla* egg population in both sets of plots was insignificant, but from August onwards, it multiplied very rapidly in both the sets. Conservation of the egg parasites was started from August. The Experimental and control plots were selected on the basis of highest and least population respectively as suggested by the Statistician so that the results may be conclusive. The preliminary egg population in set No. I ($\frac{1}{2}$ acre plots) was about 62,000 in the control and 191,000 per acre in the experimental plots. Initial egg parasitisation was 10 per cent. in both the experimental and control plots. In set No. II (in 1-acre plots) preliminary egg population in August was 282,000 in the control and 527,000 in the experimental plots with an initial parasitisation of 29 per cent. and 28 per cent. respectively.

The attack of *Pyrilla* during the year under report was rather severe. From August onwards it increased rapidly and reached its maximum in December when the egg population increased roughly 40 times more than the initial population during August. Thereafter in the month of January a decrease of about 30 per cent. was observed in the egg population due to the severe onset of winter conditions.

In all, five conservations were conducted between August, 1946 to January, 1947, in both the sets of experiments. The observations recorded after each conservation show that in set No. I in which the initial parasitisation was 10 per cent. in the experimental plots, had a significant increase every month and finally rose to 40 per cent. in January, whereas in the control plots it started with 10 per cent., increased to 22.19 per cent. by the end of August, came down to 11.50 per cent. in September and hereafter remained more or less constant. The final figure was 10 per cent. In set

No. II there was 28 per cent. and 29 per cent. initial egg parasitisation in the experimental and control plots respectively. In September the parasitisation decreased to 23 per cent. and 10 per cent. in the experimental and control plots, but thereafter it steadily increased in the experimental plots month by month and finally reached to 31 per cent. in January. In the control plots it remained more or less constant and the final figure was 10 per cent. only.

The egg population of the pest was also necessarily affected. In August the egg population in the experimental plots was 3 times more in set No. I and about 2 times more in set No. II, as compared to their respective control plots. The final figures show that the total *Pyrilla* egg population in the experimental plots after the last conservation was 871,560 in set No. I and 3,286,000 in set No. II, whereas it was 1,410,000 in set No. I and 7,909,000 in set No. II in the control plots.

The data obtained during the year under report are under analysis. The figures analysed so far show that the conservation of parasites is a fairly effective measure against the menace of *Pyrilla*. It has also proved that in larger areas with a continuous belt of crop, the multiplication of *Pyrilla* is more serious. The experiments are being repeated to confirm the above findings.

During the year under report 415,469 *Corcyra* moth, 1,295 c.c. eggs and about 16½ million *Trichogramma* parasites were bred in the parasite laboratory.

It was observed that at a constant temperature of 25° C. and 65 per cent. relative humidity the female parasites, when not allowed to mate and lay eggs, lived for a maximum period of 19, 19 and 16 days when fed with 10 per cent. glucose, maltose and fructose solutions respectively, the corresponding period for the unmated males being 6, 6 and 8 days respectively.

Fecundity studies at the same temperature and humidity as above showed that the maximum number of *Corcyra* eggs parasitised by a single fertilized female feeding on a 10 per cent. solution of glucose, maltose and fructose were 165, 157 and 238 respectively. When unfed the maximum number of *Corcyra* eggs parasitised by a single female was 93. The experiments are being repeated.

The eggs of the wax moth *Galleria mellonella* and that of the grain moth *Corcyra cephalonica* were tried as alternate hosts for the mass breeding of *Phanurus beneficiens*, the egg parasite of the top-borer *Scirpophaga nivella*. The results obtained are not conclusive. Experimental parasitism are being continued with new technique.

The possibility of breeding *Stenobracon deesae* on *Galleria mellonella* was studied. Eggs of *Corcyra cephalonica*, *Pyrilla*, *Dysdercus cingulatus* were tried as alternate hosts for *Azotus* and *Encarsia*, the parasites of the white-fly of sugarcane. The results are inconclusive.

To study the effect of sap concentration and composition on the incidence of *Pyrilla* an experiment has been started with three different manures, viz., Ammonium sulphate, Potassium sulphate and Superphosphate in five different treatments, viz., (1) Farmyard manure, (2) superphosphate, (3) nitrogen, (4) superphosphate and nitrogen and (5) potassium, superphosphate and nitrogen. The fertilizers applied were at the rate of 150 lbs. of nitrogen, 100 lbs. of P_2O_5 and 80 lbs. of K per acre. The experiments are still in progress, and the incidence of *Pyrilla* are under study.

Field experiments for the control of top-borer, *Scirpophaga nivella* by the parasite, *Phenurus beneficiens* and *Pyrilla* by *Epipyrops melanoleuca* have been laid out in the month of March, 1947. The experiments are in progress.

5. *Termites and their control*.—All the three forms (a, b and c) of *Cyclotermes obesus* were observed throughout the year, while a and b were more common during November to March and c during July to October and April to June. Their food

included dry grass, wood, sugarcane setts, bark of *Acacia*, *Engenia*, *Cajanus*, *Melia*, *Dalbergia*, *Ficus*, *Zizyphus*, etc., *Microtermes obesi* was a less common species found damaging wheat roots and wood, while *Eremotermes paradoxalis* also damaged sugarcane setts.

Experiments on the control of termite attack to wheat plants were performed with D.D.T., 666 and Diathane with four replications in each case. Soil treated with 1.25 per cent. D.D.T. emulsion before or after sowing gave the best results with a maximum yield varying from 6.7-62 lbs. per plot of 1/160th acre. On the other hand the termites were active in the plots where wheat seeds treated with 5 per cent. D.D.T. emulsion or 0.5 per cent. 666 or soil treated with 0.5 per cent. 666 (D 025) at the rate of 20 lbs. per acre or 4.76 per cent. Diathane at 320 gallons per acre. The control plots showed the maximum damage varying from 4.45 per cent. to 8.1 per cent. the average being 5.49 per cent. *Microtermes obesi* was responsible for the damage to wheat roots.

Last year's experiments on the efficacy of chemical control against termite attack on sugarcane did not give conclusive results. But this year the experiments were repeated with five replications using D.D.T., 666, lead arsenate and paris green. All the ungerminated setts when dug out and examined, showed 0.77 per cent. attack of eye-buds in the setts planted in one of the five plots treated with 1.25 per cent. D.D.T. emulsion and the same extent of damage was also noticed in setts treated with a mixture of 2 per cent. paris green and 4 per cent. lime. Other plots where setts were treated with 5 per cent. D.D.T., a mixture of 1 per cent. lead arsenate and 10 per cent. lime or with 0.5 per cent. 666 powder, or in soil treated with 0.5 per cent. 666 powder, showed 1.54-3.85 per cent. injury to setts against a maximum damage of 5.39 per cent. in control plots. The three forms, *Cyclotermes obesus* and *Eremotermes paradoxalis* were responsible for damaging cane setts.

6. *Insecticides and fumigants*.—Studies on the insecticidal properties of opium and tobacco were continued.

(a) Dusting of opium (treated with 5 per cent. acetic acid) at 40 lbs. per acre on cowpea gave a reduction of 67.6 per cent. on the fourth day and 89.2 per cent. on the ninth day in the population of *Empoasca devastans* after the first application and a further reduction of 92.1 per cent. on the fourth day and 93.1 per cent. on the seventh day after the second application against a natural reduction of population of 15.6 per cent., 59.2 per cent. and 62.9 per cent., 63.7 per cent. respectively in the control plots. Crude opium in nature and field caused a reduction of population of 30-40 per cent.

Opium smoke by burning 5 grams of marc when passed for one minute through a litre flask containing 4-5 weeks old adults of *T. castaneum* and full-grown larvae of *C. cephalonica* gave up to 100 per cent. mortality. Smoke from 20 grams of marc on the other hand when passed through a 75 c.ft. receptacle containing the same pests gave 50-80 per cent. mortality.

(b) Tobacco standard decoction of sixty-two leaf samples supplied by the Head of the Division of Botany was tested against full-grown larvae of *C. cephalonica*. Three samples of the first harvest and one of the second harvest gave a maximum kill of 90 per cent. of the pest.

7. *Control of House-flies and Mosquitoes*.—(a) Experiments on the control of house-flies were carried out throughout the year by burying cattle dung in pits covered with a 4"-6" layer of packed earth or spread out in the field in thin layers of 2"-3". In the former case maggots died of suffocation and heat due to fermentation. The incoming adult flies into the Institute area from the adjoining villages were captured by means of fly traps using decomposed mustard oilcake as bait. The number thus captured

10. *Immature stages of Indian insects.*—Studies on the immature stages of Indian insects were continued. Thirty-five published plates were checked as regards their accuracy. The life-histories of *Harpactor fuscipes*, *Melanagromyza phaseoli* and *Ceratina viridissima* were studied and plates drawn.

11. *Predators and Parasites.*—The following were the predators recorded—*Coccinella septempunctata*, *Chilomenes sexmaculata*, *Chrysopa* sp., *Brumus saturalis*, *Coranus spiniscutis*, *Harpactor fuscipes*, *Laius* sp., *Scymnus nubilus*, *Syrphus boeticus* and *Ischiodon scutellaris*. The parasites *Apanteles* spp. were reared from *Euproctis lunata*; *Microbracon* sp. from *Marasmia trapezalis*; *Fileanta rufocauda* from *Agrotis* sp. and *Sturmia atropivora* on *Acorontia styx*.

12. *Taxonomic studies of insect groups of economic importance:*—

(a) *Parasitic Hymenoptera.*—Studies on the systematics of this group were continued.

(b) *Isoptera.*—Work on the taxonomy of this group was taken up by the newly introduced school of research.

(c) *Other groups.*—Studies on the Indian Acrididae were also continued.

13. *Imperial Pusa Collection.*—During the year under review 200 specimens comprising 20 species of Diptera and 6 specimens comprising 3 species of Rhynchota were registered and card catalogued. 20 species received back after identification from Imperial Institute of Entomology, London, were added to the Collection. 119 species of insects received as donation, 111 from Forest Entomologist, Dehra Dun, were added to the Collection. In all 550 species of named insects were given as donations, 121 to Dr. A. J. Faruqi, Department of Zoology, Agra College, Agra; 429 to the Plant Protection Adviser to the Government of India; and 6 to the Forest Entomologist, Dehra Dun.

14. *Resistancy of Sesamum Spp., to Antigastra catalaunalis larval attack.*—Experiments were conducted in an attempt to find out the exact cause or causes rendering immunity or otherwise in the *Sesamum* spp., occurring in India either as cultivated or wild plants to the larval attack of *Antigastra catalaunalis*. As no distinctive physical features were discernible which would cause such resistancy, refractometer values of the sap of the leaves of the three species were taken in order to find their correlation with their resistancy observed in nature. The following ranges were obtained:—*Sesamum orietale* (Cultivated species)—1.344-1.346 *S. indicatum* (Hybrid species)—1.338-1.340. *S. prostratum* (wild species)—1.351-1.352. Detailed chemical analysis of the leaves to find out the chemical factor or factors causing this immunity are under study.

II. ADVISORY WORK

Among advisory work mention may be made of the following:—

- (i) Information regarding the univoltine race of silkworm was supplied to Mr. J. N. Das, Silk Industry Organizer, Orissa.
- (ii) *Lasioderma serricorne*, a beetle infesting tobacco seeds was identified for Head of the Division of Botany and control measures suggested.
- (iii) A sample of wada glass received from Australia was fumigated and health certificate given.
- (iv) Ten lots of insects were sent to Specialists for study and return. 929 pinned specimens of *Apanteles* sp. were given for identification to Prof. M. S. Mani of St. John's College, Agra.
- (v) 127 coloured plates illustrating the life-histories of different species of insect pests were supplied to various correspondents in India.

- (vi) Four papers were examined in detail and reported upon regarding their suitability for publication.
- (vii) An enquiry regarding some common names of Tabanid flies from the Assistant Director, Malaria Institute, was answered.
- (viii) Information regarding the insecticidal value of a perennial shrub, *Adhatoda vasica*, was supplied to the Secretary, I.C.A.R.
- (ix) Aphids (*Rhopalosiphum pseudobrassicae*) attacking brassica plants under pot-culture experiments in the Division of Chemistry were controlled by spraying tobacco decoction.
- (x) A seed-godown of the Agricultural Division was disinfected by spraying 4 per cent. solution of D.D.T. in kerosine.
- (xi) 9 samples of wheat meant for export to Palestine, 6 of oats for Canada, 20 of different crops for U.S.A. and 8 for Australia were fumigated for Head of the Division of Botany.
- (xii) Information about the moths of *Attacus* and *Actias* sp. was supplied to Mr. A. H. Scherrer of Switzerland.
- (xiii) Methods of controlling ants were suggested to the Registrar, Delhi University.
- (xiv) Information on the bunchy top disease of bananas together with its method of control was sent to the Director, I.A.R.I., New Delhi.
- (xv) Control measures against rats attacking paddy fields were recommended to the Agricultural Survey Officer, Andamans.
- (xvi) Information about the species of *Trichogramma* found in India was sent to a correspondent in California.
- (xvii) The following insects were identified: (1) 12 species of Coleoptera, 7 from Prof. Bhattacharya of Allahabad, 4 from the Mycology Division and 1 from Director, Zoological Survey of India; (2) 1 species of Rhynchota from the Mycology Division and (3) 11 species of Hymenoptera from Imperial Pusa Collection and those bred in the Insectary.

III. PROGRAMME OF WORK

I. *Discovery and control of Insect Vectors of the Virus Diseases of Indian crops.*—

(i) Field-scale trials of sprays for the white-fly vector of tobacco leaf-curl disease will be made in co-operation with some Provincial Entomologists and the Central Tobacco Committee, (ii) survey of the white-fly and other sucking types of insects causing virus diseases on economic crops like potato, papaya and castor.

II. *Insect Population Studies.*—(i) Development and standardization of technique and population study, (ii) study of fluctuation of populations of spotted bollworms in relation to biotic and climatic factors (as per programme approved by the Indian Council of Agricultural Research).

III. *Pests of stored foodstuffs.*—(i) Experiments on the control of pests of jowar will be continued and special attention will be paid to fumigation and inert dusts (as per programme approved by the Indian Council of Agricultural Research), (ii) work on the control of dry fruit pests will be continued and special attention will be paid to the method of heat sterilization of infested material, (iii) pests of stored pulses, similar to work of jowar pests (as per programme approved by the Indian Council of Agricultural Research).

IV. *Biological Control of Pests of Sugarcane*.—Field-trials with *Trichogramma* and detailed study of other potential natural enemies (as per programme approved by the Indian Central Sugarcane Committee).

V. *Termites and their control*.—Systematic and biological studies and control work of termites common in Delhi and Karnal.

VI. *Insecticides and Fumigants*.—Trials of known insecticides like D.D.T. and 666 fumigants and work on insecticides made from indigenous materials, like tobacco and waste products in opium manufacture.

VII. *Control of House-flies*.—Field-scale trials of various methods.

VIII. *Insect Pests of Potato*.—Particular attention will be paid to the potato moth and the potato jassids and potato aphids.

IX. *General observations on Indian insects of economic importance*.—Keeping records of the seasonal occurrence and abundance of those insects found associated with crops. Vigilant watch for insects assuming or likely to assume pest status.

X. *Immature stages of Indian insects*.—Studies of immature stages of Indian insects and their mode of damaging crops.

XI. *Predators and parasites*.—General biology of promising parasites and predators of insect pests of India will be continued.

XII. *Standardisation of technique for fumigation of imported fruits against codling moths*.—(As per programme approved by the Indian Council of Agricultural Research).

XIII. Investigations on the effect of different intensities of light on the reproductive power of sucking insects and on the degree of susceptibility or resistance of different varieties of tobacco to their attack.

XIV. *Taxonomic studies of insect groups of economic importance*.—Studies on Indian Parasitic Hymenoptera, particularly Ichneumonidae, Diptera of Agricultural importance (Agromyzidae Trypetidae and Tachinidae); Rhynchota particularly Aphididae and Isoptera will be continued.

XV. *Imperial Pusa Collection*.—Building and maintenance of a reference collection of insects of India.

REPORT OF THE DIVISION OF MYCOLOGY

I. INTRODUCTORY

The shortage of staff complained of last year still continues; in fact during the year under review it has been further depleted; and therefore the programme laid down for this Division could not be wholly carried out.

During the year under review Dr. B. B. Mundkur, Second Mycologist was transferred to the Bureau of Plant Protection and Quarantines as Chief Mycologist; as yet the vacancy has not been filled.

Dr. R. Prasada was appointed Assistant Mycologist from 23rd September 1946.

II. DISEASES OF PLANTS

1. Wheat (*Triticum vulgare*).

(i) LOOSE SMUT: [*Ustilago tritici* (Pers.) Rostrup].—Forty-one varieties evolved by the Division of Economic Botany which were infected the previous season to test the resistance to this smut were planted this season; as in previous years, for these tests two isolates L₁ and L₂ were used. The following results were obtained:—

L₁—Twenty-four varieties did not take the infection; twelve varieties were susceptible up to ten per cent.; and five varieties were susceptible more than 10 per cent.

L₂—Twenty-six varieties did not take the infection; varieties were susceptible up to 10 per cent. and the rest above ten per cent.

Of these 41 varieties there were 21 which did not take the infection with either of these two isolates; they were N.P. 768, N.P. 770, W5 (7-27-5), W5 (12-18-10), W5 (173-26-2), W6 (108-11-1), W6 (195-4-6), W7 (125-8-9), W7 (125-12-13), W7 (125-14-9), W9 (326-20-1), W8 (232-17-5), W9 (191-20-5), W10 (52-27-7), I.P. 937, I.P. 748, I.P. 758, W7 F9. PL 3, W9 F9. PL 4.

The following varieties were susceptible to both these isolates:—

N.P. 771, W5 (1-19-5), W9 (88-23-5), W10 (52-27-7), I.P. 741, I.P. 745, I.P. 760, I.P. 761, I.P. 762, I.P. 764, I.P. 766, I.P. 773.

Three highly susceptible varieties, *viz.*, Punjab 8A, C. 518 and C. 591, were at the same time infected with the two isolates to serve as controls; but they showed very low susceptibility; the infection was only up to three per cent.; in the previous year the infection was below 12 per cent.; this is unusual because these three varieties have been known to take the infection almost up to 100 per cent.

Forty-four varieties of C.P. wheats that were infected during the 1945-46 season were planted in 1946-47 season; the results of these trials are not very convincing. Mr. Ekbote, the Wheat Specialist, Wheat Research Scheme, C.P., writes "I believe the absence of any infection even in some of the susceptible strains like AO 49, AO 88, AO 99, etc., is due to the season being very dry all through".

(ii) *Physiologic races*.—This investigation was continued once again during the year under review and has not given any conclusive result; therefore, this investigation will now be discontinued.

Six smut collections were sent to the Division of Botany and Plant Pathology, Dominion Laboratory of Plant Pathology, Manitoba, Canada, in 1943 with the request to compare our collections with races of loose smut originating in Canada. Dr. Hanna,

Officer-in-Charge, has kindly supplied the results of these tests; according to him "there is pretty good evidence to indicate that at least three physiologic races are represented" in our six smut collections; further more he thinks that the races represented in our collections are distinct from the four Canadian races; isolates Nos. L₁, L₂ and L₃ appear to belong to one race; L₄ to a second race; L₅ and L₆ to a third race.

(iii) *Karnal Bunt*: *Neovossia indica* (Mitra) Mundkur.—Three different isolates of this smut were maintained in cultures to see if the development of sporidia was affected in successive subcultures; in two of these isolates the sporulation was markedly decreased in successive generations but the third isolate continued to sporulate abundantly in the repeated transfers.

From January to March a large number of wheat ears of several varieties and of varying ages were inoculated in different ways with sporidial suspensions and at different times of the day but none of these experiments gave positive results.

2. Jowar (*Sorghum vulgare*).

Long smut: *Tolyposporium ehrenbergii* (Kuhn) Pat.—All attempts to reproduce the disease by artificial inoculations have once again failed; the ears were inoculated in various stages of their growth and in different ways.

3. Pigeon Pea (*Cajanus cajan*).

Wilt (*Fusarium udum* Butlar).—Twenty-eight varieties and cultures raised by the Division of Economic Botany were tested for resistance to wilt disease. Five varieties, I. P. 80, I.P. 41, A126-4-1, D16-17-2 pt. 3, D16-17-2 pt. 12, completely failed to take the infection; three varieties, C38, Halwazin 39-10B, I. 69 X UP 132 F₂—pt. 2 proved to be highly susceptible the percentage of infection being 93.3, 66.6 and 60.0 respectively. For these trials unsterilized soil heavily infected with cultures of the fungus and with wilted pigeon pea stalks of the previous season were used. In another experiment one lot of soil was sterilized and another lot not sterilized before it was heavily infected; two varieties, I.P. 69 and N.E. (a) were tried for this experiment; it was seen that the percentage of infection in the sterilized soil was much greater than in the unsterilized soil; in the sterilized soil I.P. 69 and N.E. (a) became infected to the extent of 93.2 and 73.2 per cent, whereas in the unsterilized soil the percentage of infection was 40.0 and 46.6 respectively. This problem is being further investigated.

4. Gram (*Cicer arietinum*).

As already stated in my previous report a number of organisms have been isolated from diseased plants and these plants do not all show the same pathologic symptoms, nor do all of them show the presence of a pathogenic organism. Field observations and collections of diseased plants in the Institute area were made at regular intervals; collections were also made from Karnal and Ferozepore. Isolations from diseased plants in many cases remained sterile. The following fungi were isolated from specimens collected from the Institute area.—*Fusarium* spp., *Rhizoctonia bataticola* (Taub.) Butler and *Operculella Padwickii* Kheswalla; from specimens collected from Karnal were isolated *Fusarium* spp., *Rhizoctonia solani* Kuhn, *R. bataticola*, *Sclerotium Rolfsii* Sacc. and *Operculella Padwickii*; from Ferozepore specimens only *Fusarium* spp. were isolated. From specimens received from Gwalior were isolated *Fusarium* spp. and *Operculella Padwickii*. In the Institute area it was noted that *Fusarium* spp. was isolated from diseased plants throughout the gram season; *R. solani* and *R. bataticola* were isolated from young diseased plants only occasionally, but from older diseased plants these sclerotial fungi were isolated in a large number of cases; *Operculella Padwickii* was isolated only from mature diseased plants.

Operculella Padwickii was not isolated from diseased plants last year (1946-47); *Sclerotinia sclerotiorum* (Lib.) de Barry and a bacterium were isolated from diseased plants in 1945-46 but last season these organisms were not obtained from diseased plants.

The following symptoms were noted in the naturally diseased plants:—

(i) *Bronzing of leaves*.—In a majority of cases isolations from very young plants showing this bronzing of leaves remained sterile; from older plants *Fusarium* spp. and *Rhizoctonia* spp. were isolated.

(ii) Yellowing of the upper leaves, the leaflets remaining normally open; no parasitic organism was isolated from plants showing this type of the symptom.

(iii) Yellowing of the lower leaves, which later turn brown; the leaflets fold upwards; in some cases the leaflets drop prematurely; from plants showing these symptoms *Operculella Padwickii* has been isolated.

(iv) Yellowing of leaves followed by shedding of the leaflets from bottom upwards. The fungi isolated from plants showing these symptoms were *Sclerotium rolfsii*, *Rhizoctonia bataticola*, *R. solani* and *Operculella padwickii*.

(v) Wilting: *Fusarium* spp. have been isolated from these plants.

Plants which were artificially inoculated with *Fusarium orthoceros* App. & Wr. *Rhizoctonia bataticola*, *Sclerotium rolfsii* and *Operculella padwickii* showed typical field symptoms; those inoculated with *Fusarium orthoceros* showed signs of wilt; those inoculated with the sclerotial fungi showed yellowing of the lower leaves and premature shedding of the leaflets; the shedding gradually extended upwards; the bare leaf stalk remained normal and stiff. Plants inoculated with *Operculella padwickii* showed yellowing of the lower leaves; the leaflets later turned brown and folded upwards; in some cases the leaflets dropped and the leaf stalk curved upwards.

Microscopic examination of the roots of healthy plants showed the presence of hyphae in the tissues of lateral rootlets; in February and March the presence of the hyphae was more marked; the rootlets examined were externally healthy and normal. The hyphae were usually broad, granular, hyaline and unseptate, like those of a member of the phycomycetes. In February and March oospore and sporangia-like bodies were found in the root tissues. The sporangia-like bodies were terminal or intercalary, ovate in shape. This fungus has been isolated on agar media; it looks like a *Pythium*. In some cases broad granular septate hyphae showing a slight colouration were also found; so also were seen thin hyaline septate hyphae. *Fusarium* sp. and *Rhizoctonia bataticola* have also been isolated from some of these rootlets from healthy plants.

5. Potatoes (*Solanum tuberosum* L.)

(i) *Late blight*: *Phytophthora infestans* (Mont.) de Bary.—At Kufri (Simla Hills) late blight was first seen about the middle of July 1946, and by the end of the month the cultivators' crops were badly infected.

Cultures of *Phytophthora infestans* were used for testing the resistance or susceptibility of potato hybrids and cultures evolved at the Potato and Wheat Breeding Station at Simla. Of the 103 varieties tested, 22 were found to have failed to take the infection, 74 were successfully infected and the remaining seven gave doubtful results.

The *Phytophthora* isolated from diseased tubers in 1945 and 1946 at Kufri has been definitely established to be new to science and has been named *Phytophthora himalayensis* Dastur.

The *Phytophthora* which has been found at Simla and at altitudes lower than Simla, to cause a leaf rot, is considered to be *Phytophthora parasitica* Dast. which was originally isolated from castor seedlings; there are no morphological differences between

these two fungi though there are differences in their physiology and in their infective capacity but the differences are not considered to be so significant as to establish a new species.

(ii) *Early blight: Alternaria solani* (E. & M.) Jones & Grout.—The cultures of the fungus taken from potato plants showing two distinctly different types of symptoms of the disease do not show any morphological differences; plants inoculated at Delhi with either of the two cultures gave the typical early blight symptoms, brown spots with concentric rings.

(iii) *Resistance of potato tubers to infection by some important fungi found under storage conditions*.—For lack of material these trials could not be carried out last season.

(iv) *Virus diseases of potatoes*.—Plants of a number of potato varieties exhibiting different disease symptoms were analysed for their virus content. Plants of hybrid No. 96 and hybrid No. 819 indicated the presence of a hitherto unrecorded *Solanum Virus* 8. The other viruses indicated by tests on differential hosts have already been recorded.

(v) *Seed Potato Certification*.—The annual examination of the crop was made as usual. In the plains of the United Provinces and Bihar an extensive survey of virus diseases of the potato crop was made and it was once again found that the crop raised from the seed material obtained from Farrukhabad showed generally a high disease incidence. The average incidence of severe types of virus diseases ranged from 30 to 62 per cent.; but only 5 to 10 per cent. incidence of the disease was found in the crop raised from seed from Bihar. The crop in Bihar-Shariff generally exhibited a disease incidence below 6 per cent. In Patna and Bihar-Sharif some fields however, showed a disease incidence of up to 25 per cent.

In the hills of the Punjab the incidence of severe types of diseases varied from 0.4 to 5.6 per cent. The insect incidence in certain places in Simla hills was also recorded; highest insect activity was observed in the month of June.

Testing in the insect-proof house.—Tubers of varieties *Up-to-date*, *Darjeeling Red Round*, Hybrids, Nos. 2, 9 and 12 which had been raised at Kufri were indexed and tested on differential hosts in the glass house at Delhi. The selected disease-free tubers will be used for multiplication purposes. Plants raised from three thousand sprouts of *Phulwa* and *Gola* were also tested for their virus content.

Selection of Virus-free material in the field.—Tubers of apparently healthy plants of varieties *Majestic*, *Darjeeling Red Round* and *Up-to-date* which were selected and raised at the Central Seed Potato Certification Station, Kufri, in September 1945, were planted in hill units in May 1946. Diseased plants and those not true to type were rogued out.

All the selections of *Darjeeling Red Round* and *Up-to-date* which appeared to be free from disease and were true to type were retained for further studies and test in the insect proof glass house at Delhi. In addition to the above material three potato Hybrids, Nos. 2, 9 and 12 received from the Division of Botany were planted at Kufri in May 1946 and were examined for the production of healthy nucleus seed. All these hybrids showed apparent disease incidence of 95 per cent. Hybrid No. 2 mostly exhibited mosaic symptoms, whereas hybrids 9 and 12 were mostly infected with leaf-roll virus.

In order to obtain apparently disease-free plants of *Phulwa* variety, selections were made from the growing crop in the area of the Division of Mycology at Delhi. These selections will be further tested in the glass house.

Potato Test-Plots.—Test plots were laid out in different localities of the main potato growing areas of the Punjab, the U.P. and Bihar in order to determine the relative

spread of virus diseases. *Phulwa* seed material was planted in small plots in cultivators' holding amidst plots of plants with ordinary commercial seeds. Tubers raised from the test plots will be examined for virus content by growing these in the experimental plots at Delhi.

(vi) *General*—(a) *Mode of Transmission of Solanum Virus I.*—Investigation for the mode of transmission of this elusive virus was continued. Preliminary experiments indicate that the virus may be transmitted by dust storm, rain and leaf contact. The experiments to confirm the spread of the virus by root are yet incomplete. Further work in this direction will be continued next season.

(b) A study of alternate hosts of common potato viruses was undertaken and several weeds commonly found growing in the potato fields are being examined. Analytical work of their virus content will now be undertaken.

(c) Experiments to study the effect of masking of mosaic symptoms in relation to yield were undertaken. The preliminary data indicate a direct correlation between the period of masking of symptoms and the yield of the respective plants as compared to healthy plants.

(vii) *Seed Potato Multiplication Scheme—Distribution of seed potato.*—Provincial and State governments were supplied with 2,780 maunds of seed potatoes in 1946. These seeds were from crops raised at Hapur and Karnal. About 270 maunds of the raised seeds from Karnal had to be discarded because of the poor keeping quality. At the end of the season a balance of about four hundred maunds of seed could not be sold as seed, as at the last moment the Punjab Government that had asked for two thousand maunds of seed cancelled their requisition.

The yield from this seed was reported to be satisfactory. At Hapur the disease incidence in the crop raised from the seed supplied by us varied from 2 to 4 per cent., whereas the disease incidence was about 40 to 80 per cent. in crops raised from seeds from other sources; the yield per acre from seed supplied under the scheme was 200 maunds as against about 135 maunds per acre obtained by growers generally at Hapur.

On account of the unsatisfactory results obtained from crops raised at Karnal, the Scheme was reorganized. The whole lot of the required seed for 1946-47 was purchased from crops raised by the cultivators at Hapur. The fields from which the seed was to be purchased were surveyed in U.P. and Bihar and fields showing a low incidence of the disease were selected. At Hapur (U.P.) 38 acres of fields of *Phulwa* showing disease incidence of about 4 per cent. were selected. The crop was examined from time to time for virus and other diseases; and diseased plants were rogued out. Tubers not exceeding one-and-one-fourth inches in size were purchased as seed. The quantity of seed stored in cold storage at Hapur was 3,595 maunds.

Virus.—A study of a number of virus diseases of vegetables, lentils, fibre plants and other crops of economic importance was commenced; their symptoms were recorded; their modes of transmission and the properties are being investigated; mosaic diseases of *Crotalaria juncea*, *C. striata* and bronzing of *Lycopersicum esculentum* were found to be transmissible by sap inoculation, whereas mosaic of *Solanum malongana* and top necrosis of *Lycopersicum esculentum* could be transmitted by grafting.

Healthy tomato seedlings raised from seeds in an insect-proof house were transplanted in the fields from time to time from August 1946 to May 1947. The following virus diseases were found on them:—

Negligible mosaic,
Leaf-Roll,
Necrosis,
Top Necrosis, and
Smalling.

A record of insects associated with these diseased plants and also the yield from the diseased plants was maintained. A number of insects were found on the plants but *Bremissia tabaci* was found on all diseased plants except those affected by top-necrosis on which plants was found *Aphis gosypii* which was also collected from plants showing necrosis.

The virus causing the mosaic disease of *Crotalaria juncea* was crystallized. The crystals were glassy, acicular and very thin.

6. Sugarcane (*Saccharum officinarum* L.).

Red-rot: Collectotrichum falcatum Went.—During the year under review there was once again red-rot epidemic in several parts of United Provinces. The cane varieties affected were chiefly Co. 312 and "Mamchuah" a local variety, which is at times mistaken for Co. 370. A light highly sporing type of *Collectotrichum falcatum* was predominant in the numerous isolations made from infected canes collected from various localities where the disease was in an epidemic form.

Eighty-three important parent cane varieties were tested for their resistance to red-rot by inoculating them with *C. falcatum* (isolate No. 78). Judging from the linear spread of infection per cane in six months after inoculation, twenty varieties can be considered as resistant, the spread of the infection being less than fifteen inches; ten proved to be highly susceptible, the infection being up to 75 inches; and the remaining 53 varieties were found to be moderately susceptible, the infection being 15 to 30 inches. Among the varieties that took the infection very slightly are some of the popular commercial canes, e.g., Co. 356, 419, 421, 453. The varieties that were highly susceptible included Co. 213, 223, 299. Sixty out of the above 83 varieties were also tested for their resistance to red-rot infection through the nodal regions of the cane. There was considerable difference in the degree of infection in these varieties; but the general level of infection was not very high, being only 20 to 30 per cent. even in the highly susceptible varieties like Co. 213 and 299. Most of the varieties showed less than 8 per cent. infection. The failure of infection may probably be due to the unusually dry weather that followed inoculations owing to early cessation of the monsoon and lack of winter rains.

Thirty-six isolates of *Collectotrichum falcatum* isolated from different cane varieties and localities were tested on ten cane varieties, possessing greatly varying degree of resistance to red-rot; a great deal of difference in the infective capacity of these isolates was observed, but none of them showed any specific physiologic difference. The isolate from Co. 312 and "Mamchuah" canes from red-rot epidemic areas of the U.P. proved highly virulent.

Relative resistance of ratoon and plant-crop to red-rot.—Canes of the first year ratoon crop and plant crop of ten cane varieties of varying genetic composition were simultaneously inoculated with the light type of *C. falcatum* (Isolate No. 78) at Karnal. In all the ten varieties an appreciably greater amount of infection was observed in the ratoon canes than in the plant-caness. Similar results were obtained when the inoculation was made with the dark type of *C. falcatum* (Isolate No. 3).

Survival of the red-rot fungus in composting.—Cane debris from red-rot infected canes was used for making compost. Samples from the compost pit were taken every fortnight and tested for the viability of the red-rot fungus. These tests showed that the viability was lost in two to three months. In soils inoculated with *C. falcatum* the fungus was not found to remain viable for more than three months.

Smut (Ustilago scitaminea Syd).—The above mentioned 83 canes were also tested for their resistance to smut at Karnal; the setts were infected at the time of planting. Fifteen varieties showed less than 15 per cent. infection; nine showed 15 to 30 per cent.

infection; and the remaining 59 showed 31 to 100 per cent. infection. Some of the varieties, like Co. 313, Co. 524, "Katha", "Saretha", and "Chunnee", showed 80 to 100 per cent. infection. None of the important commercial varieties showed resistance to smut infection.

Saccharum spontaneum obtained from Coimbatore was found to be highly susceptible, but that obtained from Java did not take the infection.

7. Miscellaneous.

Over 400 samples of seeds to be sent abroad were examined and the necessary certificates were issued when they were found to be free from infection.

Studies in fungicides on a laboratory scale.—A beginning has been made for the study of this problem. Plants growing locally are being tested for their fungicidal properties. Preliminary tests have shown that leaf extract of *Lawsonia alba* and bark extract of *Caccia fistula* have fungicidal and fungistatic action against *Helminthosporium halodes* and *Alternaria solani*.

Study of air-borne fungal spores.—During the year under review a study of air-borne fungal spores was commenced; slides exposed in the institute area were examined every week from December 1946. A large number of spores of *Helminthosporium* and *Alternaria* were caught on the slides from March to May; a uredospore of *Puccinia graminis* was first caught on a slide exposed during the week ending 9th December 1946; eight more spores were caught during the following week; they were again trapped 10 to 17 days before the black rust was first seen on the 27th February in the Institute area; after this date large numbers of spores were seen on the exposed slides.

III. TAXONOMY.

As the Second Mycologist has left the Division and since the vacancy has not been as yet filled, not much progress in taxonomy of fungi was done during the year.

A large collection of fungi made by Professor S. L. Ajrekar at Ahmedabad, Karwar, Poona and Yellapur studied during the year. Twenty-one specimens have been completely identified and fourteen have been identified up to the genus. Some of the latter may be new species. The rest are under investigation. Out of the twenty completely identified specimens, eleven species appeared to be new records for India.

A collection of fungi was made from Mysore State from some of the adjoining parts of Bombay Province. This collection is being studied as time permits.

RUST.

Lentil—(*Lens esculenta*) *Uremyces fabiae* (Pers.) de Bary.—It has been found that teleutospores of this rust readily germinate, without a period of rest at 12°—18° C. They do not germinate at temperatures below 7° C. and above 26° C.

Teleutospores collected in April 1946 were stored at 8° C.; in December they readily germinated in tap water at room temperature. Plants inoculated with these germinating teleutospores developed pycnidia and aecidia; successive generations of aecidia were produced on these plants. Inoculations made with aecidiospores also resulted in the development of aecidia; it therefore seems that in nature the spread of this rust from plant to plant is due to this aecidial stage; the uredo stage appeared late in the season and it was soon followed by the teleutostage which was formed in the old uredo pustules.

Castor (*Ricinus communis*) Rust (*Melampsorella ricini* (Biv.) de Toni).—Fresh specimens of this rust received from Hyderabad (Deccan) by surface mail could not infect castor seedlings but those received by air mail proved to be viable; cultures of this rust could be maintained on castor plants only up to the beginning of April on account of the rise in temperature. The teleutospore stage is unknown and its formation could not be induced in our cultures; but two kinds of spores had developed, thin walled and thick walled spores. Thick walled spores predominate in old cultures and in stored material. Thin walled spores germinate readily in tap water between 8°—25° C.; all attempts to germinate thick walled spores have so far failed.

Safflower (*Carthamus tinctorius*) Rust (*Puccinia carthami* Hutz., Corda).—Uredospores germinate between 12°—26° C. A culture of this rust on its host could be maintained only up to the middle of May because of the rising temperature. The teleutospores germinated between 12°—18° C. without a resting period.

Gram (*Cicer arietinum*) Rust *Uromyces ciceris-arietini* (Grogg.) Jacz. & Boyer.—This rust was first observed in the fields on the 31st March. A culture of this rust could be maintained only up to the second week of May on account of the summer temperature.

IV. INDIAN FUNGI CULTURE COLLECTION.

The total number of live fungi and bacteria in our collection is 691. There were thirteen new acquisitions during the year.

Investigations have been commenced to see if the routing transfer of the various fungi can be done at much longer intervals than at present. It has been found that certain fungi belonging to *Ascomycetes*, *Basidiomycetes* and *Deuteromycetes* remain viable for at least a period of eight months if the usual cotton plug of the culture tube is replaced by a cellophane seal; a description of this method has been recently published. Cultures of fungi like *Aspergillus niger*, *Cephalotheca reiniformis*, *Saccharomyces Cerevisiae*, *Helminthosporium halodes* on P.D.A. to which has been added enough quantity of sterilized "Nujol" to cover the fungal growth remain viable for at least five months.

V. HERBARIUM.

One hundred and thirteen specimens from our collections were supplied to teaching institutions and research laboratories.

On an exchange basis specimens of Indian fungi were supplied to the University of Wyoming, U.S.A., Mycological Herbarium, Madison, Wis., U.S.A. and Naturhistoriska Riksmuseet, Botaniska Afdelningen, Stockholm, Sweden.

Two *Exsiccati* sets, *Cryptogames* de l'Empire Colonial Français and *Myriangiales Selecti Exsiccati*, were presented to the Herbarium by Dr. B. B. Mundkur to whom my thanks are due.

During the year 138 named specimens were added to the Herbarium.

VI. ADVISORY.

A large number of inquiries were received from all over India on various subjects; requests were received to identify pathologic and taxonomic specimens, for supplying references to literature, for supplying information regarding the distribution of certain

fungi; these inquiries are received not only from Departments of Agriculture but also University workers; more than 130 inquiries were replied to during the year.

VII. PROGRAMME OF WORK (1947-48).

I. Plant pathological investigations:—

- i. Physiologic specialisation and modes of transmission of some cereal smuts (loose smut, flag smut and bunt of wheat, long and head smuts of jowar, other smuts).
- ii. Studies in antibiosis and bacteriostatic and fungistatic substances with special reference to plant pathogens.
- iii. Studies in fungicides on a laboratory scale.
- iv. Study of suitable spray and dusting machinery.
- v. Testing the disease resistance of crops evolved at the Imperial Agricultural Research Institute.
- vi. Potato diseases: Viruses: selection of virus-free material tuber indexing; certification; multiplication of disease-free seed tubers; early and late blight; potato storage rots.
- vii. Tomato virus diseases.
- viii. Sugarcane disease with special reference to parasitic specialisation in the red-rot organism.
- ix. Miscellaneous diseases.

II. Mycological investigations:—

- i. Taxonomy of fungi with special reference to rusts, smuts and the genus *Fusarium*.
- ii. Maintaining the Indian Type Culture Collection of fungi.
- iii. Advisory work on mycological problems; identification of fungi received from the Provinces and States.

III. Miscellaneous:—

- i. Maintaining a Host-index of fungi.
- ii. Preparation of card-indexes of species of fungi of genera represented in India.
- iii. Maintaining an up-to-date card-index of literature of plant pathology and mycology.
- iv. Training of post-graduate and other students.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING.

I. GENERAL.

The work of the Division is still in the initial stages of its development and research work has been on a restricted scale. Due to non-availability of suitable qualified personnel it has not been possible during the present year to increase the gazetted technical staff, and again its main work has been the maintenance of keeping in operation implements and machinery of the Agronomy Division. A number of new machine tools together with hand tools and other equipment have been procured ready for transfer to the new machine shop the first portion of which while planned has not yet been built.

One of the most important objects of the Division is generally to foster agricultural mechanisation with a view to increase operative efficiency of the Indian peasant. In practice this means that the Division will have to keep in close touch with the needs of everyday farming characteristic of our agriculture, bearing in mind at all times the limitations under which the farmer in the village works. The lines of work in this particular field fall under the following three categories:—

- (1) The improvement and modification of existing implements and methods.
- (2) The design of new and better implements and machinery which could be operated by bullocks or by simple power driven prime movers.
- (3) The adoption, after modification to suit our conditions, of new implements and machinery, both of foreign and local make.

Research is being undertaken as to the economic possibilities of working in small plots and under village conditions of a small $5/6$ H. P. Tractor which has been ordered from abroad and which can be operated in plots of $1/20$ th acre and upwards and capable of ploughing, ridging, cultivating, mowing, drilling, etc. It has also a pulley power take-off which can be used for the operation of pumps, small thrashers and winnowers, grinders etc.

Apart from the economic possibilities it has to be proved whether the air cooled engine employed in such a Tractor can stand upto continued usage in the high temperatures and dusty conditions which prevail in many parts of India, and to determine if necessary the modifications required to offset these conditions.

In an endeavour to provide an efficient and portable pump, capable of lifting a fair quantity of water from either tank, well or river, a promising type has been obtained from abroad for trial and test. It is simple and fool-proof in operation. Plans are in hand for the necessary modifications to enable it to be tested and tried under varying conditions and for its operation by bullock drive or by motor power.

The capacity of the pump is approximately 160 gallons/minute (capacity of an average Persian wheel is 50 gallons/minute) absorbing approximately $1\frac{1}{2}$ H. P.

Research is being undertaken as to the advantages of filling pneumatic tyres on bullock and other farm carts with water in lieu of air.

Samples of improved country implements from New Zealand have been obtained and these are undergoing tests and trials.

In connection with intercultivation in sugarcane a new light Row Crop Oliver Tractor, together with its self-contained implements has been purchased for test and experiments. Its usefulness and possibilities under Indian conditions as a general purpose implement are to be examined.

II. RESEARCH.

In April 1946 an experimental project on the possibilities of the usage of the Jeep in agricultural operations was decided upon in the Indian Agricultural Institute, New Delhi, as considerable interest was being shown as to these possibilities and also to the fact that a modified Agricultural Jeep was being designed in the United States and was to come on to the market at some future date. The investigations were to be directed in such a manner that the result would be of value in determining to what extent the present type of vehicle could be used under conditions prevailing in India, and the possibilities of its economic usage in filling a gap between bullock and high capital cost tractor operation.

A certain weakness was immediately apparent in the early trials when it was found that the cooling system was totally inadequate, even when working in a shade temperature of 90° F. Working at a land speed of 2½ m.p.m. in a tillage operation, caused the system to boil after only eight minute operation. An auxiliary header tank with a capacity of 3 gallons was fitted to the top of the radiator grill, level with existing header and connected to it by a pipe. This, except under extreme temperature conditions exceeding 105° F. enabled satisfactory operation to be carried out.

Due to the relatively large turning radius of the Jeep the headlands and side lands had to be at least eight yards wide. A headland of this width allows the Jeep and implement in use to turn easily without risk of damage to implement axles. These wide headlands also enable both to turn square into the work, preventing curved ends which make finishing very difficult and wasting considerable time. If soil conditions are wet or heavy a wide headland allows a driver to pick a fresh path each time, so that the headland is not unduly churned up and creating wheel slip. Final cultivation of the headlands and side-lands is rapid as during this work no lifting of the implement is necessary.

In field practice it was found that provided the Jeep was not called upon to exert a draw bar pull exceeding 750 lbs. the clutch facings did not suffer undue wear, provided also that the driver at all times exercised due care in take-off and that no attempt was made at any time to slip the clutch. Draw bar pulls exceeding 1,000 lbs. were persevered with and clutch was rendered inoperative after a comparatively short period of operation. In this connection it may be of interest to note that a standard 'Austin' 12 clutch facing was found to be suitable as a replacement and after fitting has continued to give excellent service.

For ploughing operations the Jeep was found to be quite unsuitable. A lower gear ratio is essential, both to lower operating speeds and to increase draw bar pull and a lower hitch than the hook provided is also necessary.

Under all tests the ability of the chassis and frame work of the jeep to stand up to continue heavy operation without distortion was observed.

For transport and load hauling the vehicle was found to be quite adaptable for travelling over rough roads and open country and in a series of fuel economy road tests the following average results were obtained:—

Miles per hour.	No. load miles per gallon.	2,000 lbs. load miles per gallon.
20	22	16
30	19	..
40	17	..
45	14	..

Note:—Load was carried both in the vehicle itself and in standard two wheel Jeep trailer with practically similar consumption figures. All of the above tests were carried out on *pucca* roads.

A series of field tests on the Institute Farm were carried out in August and September, with soil conditions typical for that season with a nine tine spring cultivator and horse hoes. The horse hoes were used in intercultivation work in young maize crops. There it was found that no damage was done to young plants up to 20" high by the relatively low positions of certain parts comprising the Jeep chassis.

The following are the summarised averages of these tests. In most cases the actual times and consumption did not vary very much. In cases where this did happen it was caused mainly through faulty laying out of work in the Jeep causing much loss of time in finishing small left areas in cultivation and in correct counting of rows in intercultivation work.

Implement.	Width.	Depth.	Draw Bar Pull.	Fuel gals./hour.	Fuel gals./acre.	Acre per hour.
9 Tine cultivator . . .	7'	4"	800	2.25	.47	4.8
9 Tine cultivator . . .	7'	3½"	700	1.40	.34	4.1
5 Horse harrows . . .	10'	3½"	900	.67	.24	2.8

Note:—In the latter operation the Harrows were hitched in echelon to a 10' wooden beam fitted to rear of Jeep.

From the foregoing tests and observations it would appear that the Jeep can serve as useful source of power for use in the field where the purchase of a Tractor is not possible, for certain operations. On a farm using a Tractor the Jeep can pull one of the lighter and *faster* operating implements while the Tractor is used for heavier types, thus speeding up field operations. The Jeep is too low and has too great a turning radius for use in certain crops and in limited fields areas. It can however be used to great advantage in conjunction with a trailer as means of rapid transport from farm to market and *vice versa*. The maximum horse power of the engine cannot be obtained under certain agricultural conditions, such demanding a considerably lower operating speed than that at which the maximum horse power is obtained. Summarizing, from the studies and tests made, the Jeep can well serve as a utility vehicle for very light field operation and general transportation work.

2. The Agricultural Engineer continued to act as Member and Secretary of the Government of India Kans Control Committee which scheme and experiments at Bhopal have been continued for another year. The interim report has not yet been completed but results obtained so far are most encouraging. The following extract from the minutes of the meeting of Kans Control Committee held in February 1947 are quoted:

'An area of approximately 100 acres of very heavily infected Kans land, which had gone completely out of cultivation was ploughed in 1946 between 11th May and 17th June. The area was divided into four main blocks to which the following main initial treatments were applied:

- (1) Dessication—*i.e.*, deep ploughing alone;
- (2) Deep ploughing twice with an interval of one month;
- (3) Ploughing (deep) followed by picking of the Kans rhizomes and beeming;
- (4) Ploughing and beeming only.

In each main block six different crop treatments were employed and each crop treatment was replicated six times.'

"The appearance of the standing crop is in general very good. From a visual examination it is not possible at present to draw any conclusions as to the value of the

various treatments. If there is any difference this will be evident from the harvested yields. There is evidence of Kans in most plots. The extent, however, of this compared to the original conditions is a mere fraction. The amount varies but the cause of its existence is mainly due to the number of first and last furrows which the planned lay-out of the experiments has necessitated. It is proposed to rectify this in future operations. When, however, the condition of the cropped area is compared with the remaining unploughed Kans infested area the value of such ploughing is brought clearly into perspective.

In bringing this land back to productive use it must be borne in mind that heavy infestation of Kans depletes the soil fertility. The first step in rehabilitation must be to re-build fertility for crop production. It is therefore advisable to devote this area mainly to fertility building crops in the first year subsequent ploughing. For this reason legumes should be given a prominent place in the early cropping programme. In this connection the excellent stand of the gram crop suggests that this crop may be the first *rabi* to be sown after ploughing because (1) of its excellent smothering effect, and (2) of its fertility building capacity."

An extract from a letter from the Director of Agriculture, Bhopal, dated 6th April states: "All the crops have now been cut (on Kans experimental area). I made a few tests for out-turn and it comes to about 8 maunds standard for both gram and wheat. *This is about the best record for the whole of Bhopal.*"

III. ADVISORY.

An increasing number of enquiries are being received asking advice in various branches of mechanization in agriculture and for specific advice as to purchase of tractor and other machinery under different conditions.

Actual instruction and help has been given in the operation of mechanized equipment.

IV. PROGRAMME OF WORK (1947-48).

1. *Usage of walking tractors.*—(I) Field trials. (II) Modification. (III) Economics.
2. *Water lifts.*—Research and Design. Field scale trials.
3. *Pneumatic tyres for Farm Vehicles.*—Advantages and economics of water filled in lieu of air.
4. *Foreign implements—Country type.*—Field trials, and modifications.
5. *Raw Crop Tractor.*—Field scale trials.
6. *Improved type bullock gear.*—Design and trials.
7. *Threshing machines.*—Field scale trials and tests of small types.
8. *Irrigation Channels.*—Research and study of seepage losses and the possibilities of their elimination.

APPENDIX I.

Gazetted Staff of the Institute.

Director	Dr. J. N. Mukherjee, C.B.E., F.N.I., F.R.A. S.B., F.C.S.	
Assistant Director	Dr. B. P. Pal, M.Sc., Ph.D. (Cantab.), F.L.S.	
Registrar	Vacant.	
Personal Assistant to the Director.	Mr. A. M. Desai.	
<i>Agriculture.</i>		
Head of the Division	Mr. C. H. Parr, B.Sc., I.A.S.	
Agricultural Experiment- alist.	Mr. R. D. Bose, B.Sc.	Up to 13th September 1946; from 14th September Mr. Bose is on deputation as Secretary, Indian Central Sugarcane Committee from which date Mr. S. Sen, Assistant Agronomist is holding charge of the current duties of the post in addition to those of his own.
Assistant Agriculturist	Dr. A. G. Riaz, B.Sc. (Ag.), Ph.D. (Wales).	Up to 10th August 1946, when he was transferred to Agricultural Sub-station, Karnal, to officiate as Farm Superintendent there. From Karnal he proceeded on training to U.S.A. for appointment as Agronomist in the Central Soil Conservation and Land Utilization Board.
Statistician	Mr. P. V. Krishna Iyer, M.A.	Up to 13th September 1946, when he proceeded on study leave to U.K.
Assistant Agronomist	Mr. S. Sen, M.Sc.	
Farm Superintendent, Karnal.	Mr. A. R. Khan, B.Sc. (Ag.)	Up to 9th August 1946, when he proceeded on study leave to U.S.A.
	Dr. A. G. Riaz	Officiating from 10th August 1946 to 20th April 1947.
	Mr. Y. C. Gupta, B.A.	Officiating from 21st April 1947.
Cattle Superintendent, Delhi.	Mr. N. P. Fernandez, G.B.V.C.	
Cattle Superintendent, Karnal.	Mr. J. D. Sampatkumaran, L.V.P.	Up to 11th December 1946, when he proceeded on study leave to U.S.A.
<i>Botany.</i>		
Head of the Division	Dr. B. P. Pal, M.Sc., Ph.D. (Cantab.), F.L.S.	
Second Economic Botanist	Dr. S. Ramanujam, M.A., Ph.D. (Lond.).	Up to 5th June 1946; from 6th June 1946 Dr. Ramanujam has been on deputation as O.S.D. (Potato) and later as Director, C.P.R.I.
Plant Physiologist	Dr. R. D. Asana, M.Sc., Ph.D. (Lond.), D.I.C.	
Geneticist	Vacant.	
Assistant Economic Botanist.	Mr. R. B. Deshpande, M.Sc. (Ag.).	

APPENDIX I—contd.

Botany—contd.

Second Assistant Economic Botanist	Dr. J. J. Chinoy, M.Sc. Ph.D. (Lond.), D.I.C.	
Assistant Botanist	Mr. A. B. Joshi, M.Sc. Assoc. I.A.R.I.	
Assistant Botanist (Plant Breeding Station, Simla)	Mr. Harbhajan Singh, M.Sc., Assoc., I.A.R.I.	From 15th May 1947.
Superintendent and Potato Research Officer, Potato Breeding Station, Simla	Dr. Pushkar Nath, M.Sc., D.Sc.	The post is temporary.
Assistant Botanist (Geneticist), Potato Breeding Station, Simla	Mr. D. Srinivasachar, M.Sc., Assoc., I.A.R.I.	The post is temporary.
Superintendent, Botanical Sub-station, Pusa	Mr. S. M. Umar, B.Sc.	
Superintendent, Tobacco Breeding Sub-station, Guntur	Mr. T. Narayana Rao, B.Sc. (Ag.), M.A.	The post is temporary; the Tobacco Breeding Sub-station, Guntur, has been transferred to the control of the Indian Central Tobacco Committee from 1st April 1947.

Soil Science and Agricultural Chemistry.

Head of the Division	Vacant.	
Organic Chemist i.e. of the Division	Dr. R. H. Siddiqi, M.Sc., Ph.D.	From 15th August 1946 to 24th April 1947.
Second Agricultural Chemist in charge of the Division	Dr. S. V. Desai, B.Sc., D.Sc. (Lond.)	From 25th April 1947.
Organic Chemist	Dr. R. H. Siddiqi, M.Sc. Ph.D., D.Phil. (Oxon.)	
Soil Survey Officer	Dr. S. P. Ray Choudhury, D.Sc., Ph.D. (Lond.)	Up to 20th April 1947, proceeded on leave to U.S.A. for appointment as Soil Scientist in the Central Soil Conservation and Land Utilization Board.
Physical Chemist	Vacant	
Soil Chemist	Vacant	
Assistant Agricultural Chemist	Dr. S. Das, M.Sc., D.Sc.	
Second Assistant Agricultural Chemist	Mr. A. C. Ukil, M.Sc.	
Assistant Agricultural Microbiologist	Dr. N. D. Vyas	
Assistant Chemist	Dr. W. V. Balabunder Rao, B.Sc., Ph.D.	
Assistant Soil Survey Officer	Dr. R. V. Tamhane, M.Sc., Ph.D. (Lond.)	Officiating
Assistant Soil Survey Officer	Dr. K. V. S. Satyanarayana, B.Sc. (Agri.), Ph.D.	Officiating from 11th February 1947.
Assistant Physical Chemist	Vacant	

APPENDIX I—*concl'd.**Entomology.*

Head of the Division	Dr. Taskhir Ahmed, B.Sc., Ph.D. (Cantab.).	Officiating from 22nd January 1947.
Second Entomologist	Dr. Taskhir Ahmed, B.Sc., Ph.D. (Cantab.).	Up to 21st January 1947, after which date the post is vacant.
Parasitologist	Vacant.	
Biological Control Research Officer (Sugarcane Pest Scheme).	Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C.	The post is temporary.
Assistant Entomologist	Mr. H. Haroon Khan, B.Sc. (Hons.), (Lond.).	Up to 31st May 1947, when he was trans- ferred to the Sind. Department of Agriculture; Mr. C. K. Samuel, offi- ciating from 1st June 1947.
Second Assistant Entomo- logist.	Mr. B. Bose, B.Sc.	Officiating.
Assistant Entomologist	Dr. S. Mukherjee, D.Sc.	
Assistant Entomologist (Population Studies).	Dr. Ram Das Menon, B.Sc., Ph.D.	Officiating.
Assistant Entomologist, (Pulse Scheme).	Mr. C. N. Modawal, M.Sc.	Up to 12th August 1946, after he was transferred to the Department of Food; from 13th August 1946 Mr. C. K. Samuel officiating.

Mycology.

Head of the Division	Mr. J. F. Dastur, M.Sc. (Lond.), I.A.S. (Retd.).	Officiating.
Second Mycologist	Dr. B. B. Mundkur, M.A., Ph.D. (Lond.).	Up to 21st February 1947, when he was transferred to Bureau of Plant Protec- tion and Quarantine.
Virologist	Dr. R. S. Vasudeva, D.Sc. (Lond.), Ph.D. (Lond.), D.I.C.	From 20th June 1947.
Seed Potato Production Officer	Dr. R. S. Vasudeva, B.Sc., Ph.D. (Lond.), D.F.C.	Up to 19th June 1947.
Assistant Mycologist	Dr. B. L. Chona, Ph.D. (Lond.).	
Assistant Plant Patholo- gist.	Mr. S. P. Ray Choudhuri, M.Sc.	
Assistant Mycologist	Dr. R. Prasada, M.Sc., D.Sc. (Agra).	Officiating from 23rd September 1946.
Assistant Mycologist	Mr. K. F. Kheswalla, B.Sc., Assoc., I.A.R.I.	Officiating up to 30th September 1946 and again from 5th February 1947.
Assistant Virologist	Vacant.	

Agricultural Engineering.

Head of the Division	Major D. T. Brown, A.M.I., Mech. E., M.I.B.A.E.
Assistant Engineer	Mr. A. K. Kaul, L.E.E.

Sugarcane Breeding Station, Coimbatore.

Sugarcane Expert	Mr. N. L. Dutt, M.Sc.	
Second Cane Breeding Officer.	Dr. N. Parthasarathy, B.Sc. (Agri.), Ph.D. (Lond.).	
Assistant Sugarcane Ex- pert.	Mr. M. K. Krishnaswami, M.A.	
Plant Physiologist	Mr. N. D. Yusuf, M.Sc. (Cantab.).	The post is temporary.

APPENDIX II.

Training of Students and Research workers during 1946-47.

(a) List of Students Awarded Post-Graduate Diploma.

Name of Student	Title of thesis.
<i>Economic Botany.</i>	
1. Narendralal Dhawan	Interspecific hybridization in <i>Sesamum</i> L.
2. S. Basharat Ali Shah	Colchicine-induced Polyploidy in different varieties of chillies (<i>Capsicum annum</i>).
3. V. Ramamurthy	Pt. I. Studies in the seed-coat anatomy of Brassica species. Pt. II. Studies on colchicine-induced polyploidy in some Imperial Pusa types of <i>Sesamum Orientale</i> L.
4. Choudhry Mohd. Sharif Sirdar Khan.	Influence of late sowing of wheat on yield and variation in plant characters.
5. Yogendra Mohan Upadhyaya	Variability and the role of natural selection in wheat varietal mixtures and hybrid generations.
6. Shyam Narain Sharma	Effect of temperature on the development of wheat grain.
<i>Agricultural Chemistry and Soil Science.</i>	
7. Khubo Cianchand Tejwani	Effect of nitrogenous and phosphatic fertilizers on soil fertility and crop composition where legumes are either included in or excluded from the rotation (a lysimeter study).
<i>Entomology.</i>	
8. Parkash Lall Remghen	Pt. I. On the morphology of immature stages of fruit fly <i>Dacus Cucurbitac</i> coq. with short notes on its biology. Pt. II. Our present knowledge of the insect pests in India of the important edible fruits of the family Rosaceae.
9. Abdul Mannan	Pt. I. The survey of insect pests of dried fruits. Pt. II. Biology of the saw toothed nuts beetle, <i>Oryzophilus mercator</i> Fauvel with description and bionomics of one new species of the genus <i>Stathmopoda</i> . Pt. III. Thorough review on the work done on most important pests of dried fruits with a separate chapter on control measures.
10. Mohd. Mohsin	Pt. I. Studies on the role of nutrition in the longevity and fecundity of <i>Microbracon gelctise</i> Astrum, a larval parasite of potato tuber moth. Pt. II. A review of the work done in the control of sugarcane moth borer, <i>Diatraea Saccharalis</i> Fab. by its egg parasite <i>Trichogramma minutum</i> Riley.
<i>Mycology and Plant Pathology.</i>	
11. Hari Krishna Saksena	Studies in the physiology of <i>Ustilago Tritici</i> (Pers.) Rostrup causing loose smut of wheat.

APPENDIX II—*contd.* *(a) *List of Students awarded Post-Graduate Diploma—contd.**Sugarcane Breeding.*

Name of student.	Title of thesis.
12. Obaidulla Jan	Part I. Sugarcane Breeding with special reference to the work done at Coimbatore. Part II. Some studies on the influence of the size of the sugarcane setts, location of nodes and the depth of planting on the germination, tillering and final stand of the crop.
13. Om Prakash Agarwal	Part I. The activities relating to the production of Co. canes with special reference to the Breeding work at Coimbatore. Part II. Studies on the effect of Photo-period factor on growth of Sugarcane.

(b) *Students admitted during the year.**Agriculture.*

1. B. Kanungo.	9. C. L. Rathi.
2. K. R. Gahlaut.	10. Mazharul Haque.
3. Asharfi Ram.	11. G. P. Das.
4. L. J. David.	12. Mohd. Qureshi.
5. R. R. Singh.	13. R. T. Gandhi.
6. Ishwari Prasad.	14. Sitaram.
7. Harcharan Singh.	15. B. N. Mathur.
8. C. D. Dubay.	

Botany.

16. Mohd. Khan Baluch.	21. V. Swarup.
17. I. I. Choudhri.	22. S. P. Singh.
18. D. D. Sundararaj.	23. N. R. Panigrahi.
19. K. L. Nakhtore.	24. K. Ramanathan.
20. M. A. F. Faridi.	25. D. V. Ariyanayagan.

Sugarcane Breeding.

26. B. N. Trivedi.

Chemistry.

27. M. R. Chandrasekhara.	30. S. N. Kaul.
28. S. K. De.	31. M. H. Karim.
29. P. M. Joshi,	32. A. G. Khan,

° APPENDIX II—*concl'd.**(b) Students admitted during the year—contd.**Entomology.*

33. M. L. Purohit.	38. G. Vedamurthy.
34. Hukam Singh.	39. Mohd. Shafi.
35. G. C. Sen Gupta.	40. Shewaram C. Bhatia.
36. S. A. Moiz.	41. Miss S. Cameron.
37. Maheshwar Misra.	

Mycology.

42. S. K. Jain.	45. H. P. Chottia.
43. T. A. Amari.	46. T. C. Roy.
44. J. Singh.	

Plant Protection (I-Year).

47. M. S. Bhan.	50. B. S. Tavathia.
48. K. C. Sharma.	51. S. L. Joshi.
49. J. S. P. Yadava.	

(c) Students admitted for short courses of training.

Name.	Division.	Period.
1. Amar Singh . . .	Agriculture . . .	3½ months
2. V. Govindan . . .	Botany and Entomology . . .	3 „
3. K. D. Sharma . . .	Sugarcane Station (Coimbatore).	3 „
4. A. N. Misra . . .	Chemistry (Bacteriology) . . .	4 „
5. S. Basharat Ali Shah . . .	Botany . . .	1 month.
6. Ram Autar Agarwal . . .	Entomology . . .	9½ months.

(d) Honorary Research Workers.

Name.	Subject.
1. S. Govindaswamy . . .	Cytogenetics and morphological studies of inter-specific and inter-generic hybrids of Sugarcane.
2. Subrata Sen . . .	Hybrid vigour.
3. K. G. Tejawani . . .	Influence of nitrogenous and phosphatic fertilisers on soil fertility. (A lysimeter study.)
4. S. N. Sharma . . .	Plant Hormones.

(e) Research Fellows.

1. S. Sen . . .	In Botany Division.
2. N. L. Dhawan . . .	In Botany Division.
3. H. K. Saksena . . .	In Mycology Division.

APPENDIX III.

List of papers published during 1946-47.

- Chona, B. L. Simple practical Schedules for the control of Red Rot Smut and Mosaic of sugarcane (in press).
- Chinoy, J. J. (1947) 1. How drought affects Indian Wheat. *Indian Fung.*, 8: 72-74.
 2. A simple inexpensive hand-microtome. *Curr. Sci.*, 16: 24-25.
 3. A micro-glass electrode for pH determination. *Curr. Sci.*, 16: 25-26.
 4. Effect of spacing on yield of wheat. *Curr. Sci.*, 16: 121.
- Dastur, J. F. *Phytophthora* sp. on potatoes (*Solanum tuberosum* Lin.) in the Simla Hills. (In press).
- De Costa, G. C. and Mundkur, B. B. A Revision of the genus *phyllosticta* in India (in press).
- Das, S. (1946) 1. Plant food requirements of calcareous soils. I. Optimum requirements of phosphorus for Pusa calcareous soils. *Ind. J. Agri. Sci.* 16, 221.
 2. Plant food requirements of calcareous soils. II. Optimum requirements of nitrogen for Pusa calcareous soils. *Ibid.* 229.
- Das, S., Mukherjee, S. K., Sen, A. and Viswanath, B. (1946). Comparative studies on Indian soils. III. Base exchange properties. *Indian Jour. Agri. Sci.* 16: 3.
- Desai, S. V. and Mathur, M. L. (1946) Preliminary studies on calcium and phosphorus in milk and feeds of Sahiwal cows. *Ind. Jour. Vet. Sc.* Vol. XV, Part III, page .
- Desai, S. V. (1946) Combustible gas from cowdung—developing village India—*Indian Farming* special number.
- Datta, S. C. (1946) Sulphate reduction and production of elemental sulphur by bacteria. *J. Sci. Indus. Res.* 5B, 28-30.
- Gupta, B. N. (1947) A method of sealing tubes of fungal cultures to increase their longevity. *Curr. Sci.*, 16: 94-95.
- Mukherji, S. 1. "A menace on the horizon"—*Perspective* (a journal of information and Broadcasting Deptt.), Vol. 2, No. 1, 1947.
 2. "Peritrophid membrane in *Schistocerca gregaria* Forsk." *Current Science*, Vol. 16, No. 4, p. 124, 1947.
- Mundkur, B. B. and Sultan Ahmad (1946). Revision of and additions to Indian Fungi. II. *Myc. Papers* No. 18, Imp. Myc. Inst.
- Pal, B. P. 1. (1945). Studies in hybrid vigour. I. Notes on the manifestation of hybrid vigour in gram, sesamum, chilli and maize. *Indian J. Genet. Pl. Breed.*, 5: 106-121.
 2. (1946). Introducing better crop varieties Indian Fung. (Special Number—Developing Village, India), pp. 129-33.
 3. (1946). Studies in hybrid vigour II. Notes on the manifestation of hybrid vigour in the brinjal and bitter gourd. *Indian J. Genet. Pl. Breed.*, 6 (No. 1).
 4. (1947). The Imperial Agricultural Research Institute. *Indian Sci. Congr. Handbook on Delhi*, pp. 92-95.

APPENDIX III—contd.

List of Papers published during 1946-47—contd.

- Pal, B. P. and Murty, G. S. (jointly) (1946). Vernalisation response of cultivated Indian Wheat. with Sen, B. and Chakravarti, S. C.). Curr. Sci., 15: 351-52.
- Parr, C. H. (1946). Use of surplus monsoon water to increase crop production. *Indian Farming* (in press).
- Parr, C. H. and Bose, R. D. (1946). III. Phosphate manuring of legumes for increased food and fodder. *Indian Farming* (in press).
- Parr, C. H. and Sen, S. (1946). Effect of fourtimes milking and handling in cows of the Tharparkar herd. *Indian J. Vet. Sci. Ani. Hus.* (in press).
- Parr, C. H. and Sen, S. (1947). Phosphate manuring of legumes in relation to green manuring. *Proc. 34th Indian Sci. Cong.* (in press).
- Parr, C. H. and Sen, S. (1947). Effect of artificial fertilizers on the yield and quantity of a mixture of Rhodes grass (*Chloris gayana*) and lucerne (*Medicago sativa*). *Proc. 34th Indian Sci. Cong.* (in press).
- Prasada, R. (1947) 1. Studies in the Rust of linseed, *Melampsora linn* (Pers.) Lév. Abs. proc. 34th Ind. Sci. Congr., 1947.
2. Reactions of certain varieties of *Hordeum* to Indian Physiologic Races of *Puccinia triticea* (in press).
3. Rust of some of the common wild grasses in the neighbourhood of Simla (in press).
4. The Rust of Safflower, *Puccinia Carthmi* (Hutz.) Corda. (in press).
- Ramamoorthy, B. and Desai, S. V. 1. (1946). Preliminary studies on the nutritional diseases of plants and their spectroscopic diagnosis. Ind. Jour., Agri. Sci. 16, 103.
2. (1944-45). Colour standardisation for the virgin surface soils India. Proc. Ind. Soc. Soil. Sci. p. 7.
- Ramanujam, S. and Deshmukh, M. J. (1945). Colchicine-induced polyploidy in Crop Plants. III. The Oleiferous *Brassicae*. Indian J. Genet. Pl. Breed., 5 (No. 2), pp. 61-81.
- Ramanujam, S. and Singh, H. B. (1945). Narrow leaf—Another leaf mutant in Gram (*Cicer arietinum* L.). Indian J. Genet. Pl. Breed., 5: 46-50.
- Raychaudhuri, S. P. (1947) 1. A mosaic disease of brinjal (*Solanum melongena* Linn.). Curr. Sci. 16: 149-150.
2. A note on mosaic virus of sann-hemp (*Crotalaria juncea* Linn.) and its crystallization. Curr. Sci., 16: 26-28.
3. Further studies on *Diplodia cajani* Raychaudhuri (in press).
4. *Orulariopsis googypii* Wakefield var. *indica* var. nov. on Cotton (in press).
5. Saltation in *Helminthosporium cryzae* Br. de Haan. (in press).
- Roy, S. C. Anthracnose disease of piper betle L. caused by *Collectotrichum Dasturii* Roy Sp. nov. in Bengal (in press).
- Sen, A., Ukil, A. C., Mukherjee, S. K. and Viswanath, B. (1940). Comparative studies on Indian Soils. IV. Mechanical analysis of Soil Profiles. Ind. J. Agri. Sci. XVI, III.
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